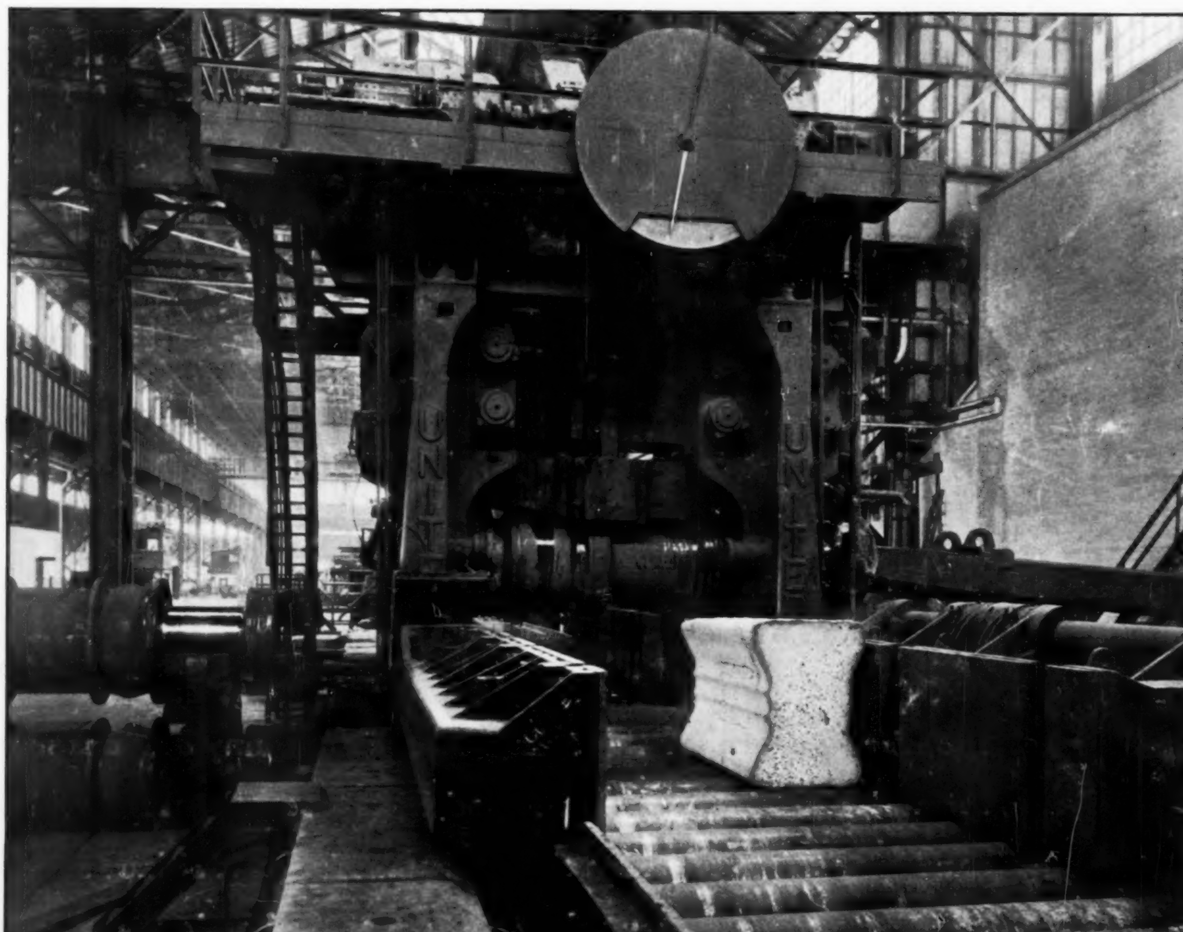
MECHANICAL ENGINEERING



Rolling an 18-Ton Ingot

January 1932

HEDGES-WALSH-WEIDNER Fusion-Welded Drum

Partially finished drum

Completed drum

FUSION WELDED DRUMS and PRESSURE VESSELS of all sizes and for all purposes

The above drum for the Standard Oil Company of Kansas was formed, electric welded, X-rayed, heat treated, tested and was ready for shipment from the Hedges-Walsh-Weidner shops at Chattanooga eight weeks from receipt of order. • All work executed in accordance with the A. S. M. E. Code for welded pressure vessels by the most modern equipment and facilities available. • Literature will be sent upon request.

COMBUSTION ENGINEERING CORPORATION
200 MADISON AVENUE • NEW YORK, N. Y.

MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 54 NUMBER 1

Contents for January, 1932

Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York, N. Y. Cable address, "Dynamic," New York. Price 60 cents a copy, $5.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage to Canada, 75 cents additional, to foreign countries, $1.50 additional. Changes of addresses must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B2, Par. 3). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . .

WHAT IT'S ALL ABOUT

WE HESITATE to direct attention to sartorial changes, but so enchanting is the name "Garamont" by which our new type face is called that we are emboldened to mention it. Unable to compose a sonnet on so significant a change, as did Christopher Morley when the *Saturday Review of Literature* adopted the same face some weeks ago, we plead no other excuse than the novelty of change and what we hope will prove to be greater readability. Our choice of type, by the way, was made months before we were aware of our distinguished contemporary's decision.

Wishing to be thorough, and realizing that new dress sometimes makes a new man, we went right through MECHANICAL ENGINEERING from cover to advertising pages, making changes in format and in the arrangement and distribution of text matter. These we look upon as improvements. The first portion of every issue is to be devoted in the future to special articles of broad general interest to all readers. The second, aside from regular departments, will be the technological section, made up of three important features: (1) The Survey, now increased to 15 pages, in which are illustrated abstracts of the important articles of the month appearing in the engineering magazines of the world, (2) Synopses of A.S.M.E. Transactions papers, with order blank, which provide digests of what the A.S.M.E. is publishing, and (3) selected items from The Engineering Index. With these three sources of information appearing regularly, every reader should be able easily to keep abreast of progress. There is also a slight technical change in the cover which we do not quite understand, but about which, nevertheless, we rejoice.

January MECHANICAL ENGINEERING is pretty much of an A.S.M.E. affair. Fortunately for mechanical engineers in particular and the engineering profession generally, neither the modesty nor the influence of Calvin W. Rice, for twenty-five years secretary and now also the most recent honorary member of the Society, were successful in deleting the appreciative address delivered by Karl T. Compton, president of the Massachusetts Institute of Technology, in which were memorialized the distinguished secretary's unique achievements, and in which also an attempt was made to interpret the philosophy of technical-society organization and administration as exemplified by the conduct of A.S.M.E. affairs. Engineers all over the world know Dr. Rice, but few fully comprehend what he has meant to the engineering profession.

CONRAD N. LAUER

TRAVELING 30,000 miles in one year, sleeping on pullmans and in strange hotels, making connections early in the morning and in the middle of the night, speaking at luncheons, at committee meetings, before student bodies, at dinners, and at gatherings of professional engineers, is no easy task, even for a man who has a congenial fondness for railroading and editorial work. This Roy V. Wright did as president of the A.S.M.E. He came to know the membership of the Society as few men have ever known it, and he carried with him, wherever he went, a message of professional idealism which he interpreted in practical and challenging terms. In his presidential address, printed in this issue of MECHANICAL ENGINEERING, he has summed up his message under the caption, "The Engineer Militant." "We need militant engineers," he says, "who will enthusiastically devote their energies to building up the engineering profession, raising it to higher levels, and who will vigorously take the offensive in helping to find a solution of some of the great economic problems which we are now facing." There's a challenge—and an opportunity!

IN THE December 7 issue of the *A.S.M.E. News*, Dr. Wright says some nice things about Conrad N. Lauer, the new president of the A.S.M.E. Mr. Lauer is one of those who has measured up to Dr. Wright's specifications for the militant engineer. His career as an engineer, and his particularly successful experiences in the field of human relations, stamp him as a leader

of this type. Readers of MECHANICAL ENGINEERING will recall that Mr. Lauer was chairman of the A.S.M.E. Committee on the Economic Status of the Engineer, whose report on "1930 Earnings of Mechanical Engineers" appeared in the September issue, with appendices in the November and December issues. They will also recall that it was Mr. Lauer who created the fund for the Hoover Medal to commemorate the public service of engineers who have achieved distinction in civic and humanitarian affairs. Under Mr. Lauer's administration the A.S.M.E. should forge steadily ahead, serving not only its members but the engineering profession and society at large.

WALLACE B. DONHAM'S recent book "Business Adrift" set many minds to thinking, and some of the scouts of the A.S.M.E. went down to the Stevens Engineering Camp last summer to hear him talk. The result was that the distinguished dean of the Graduate School of Business Administration at Harvard University soon found that he had promised to deliver the fourth Henry Robinson Towne lecture on the relation between economics and engineering at the 1931 Annual Meeting of the A.S.M.E. Dean Donham's address "Twenty-Year Plans" made a profound and favorable impression. Those who heard it will surely wish to read it. Those who missed the lecture can now make up for their loss by reading the original.

ROY V. WRIGHT

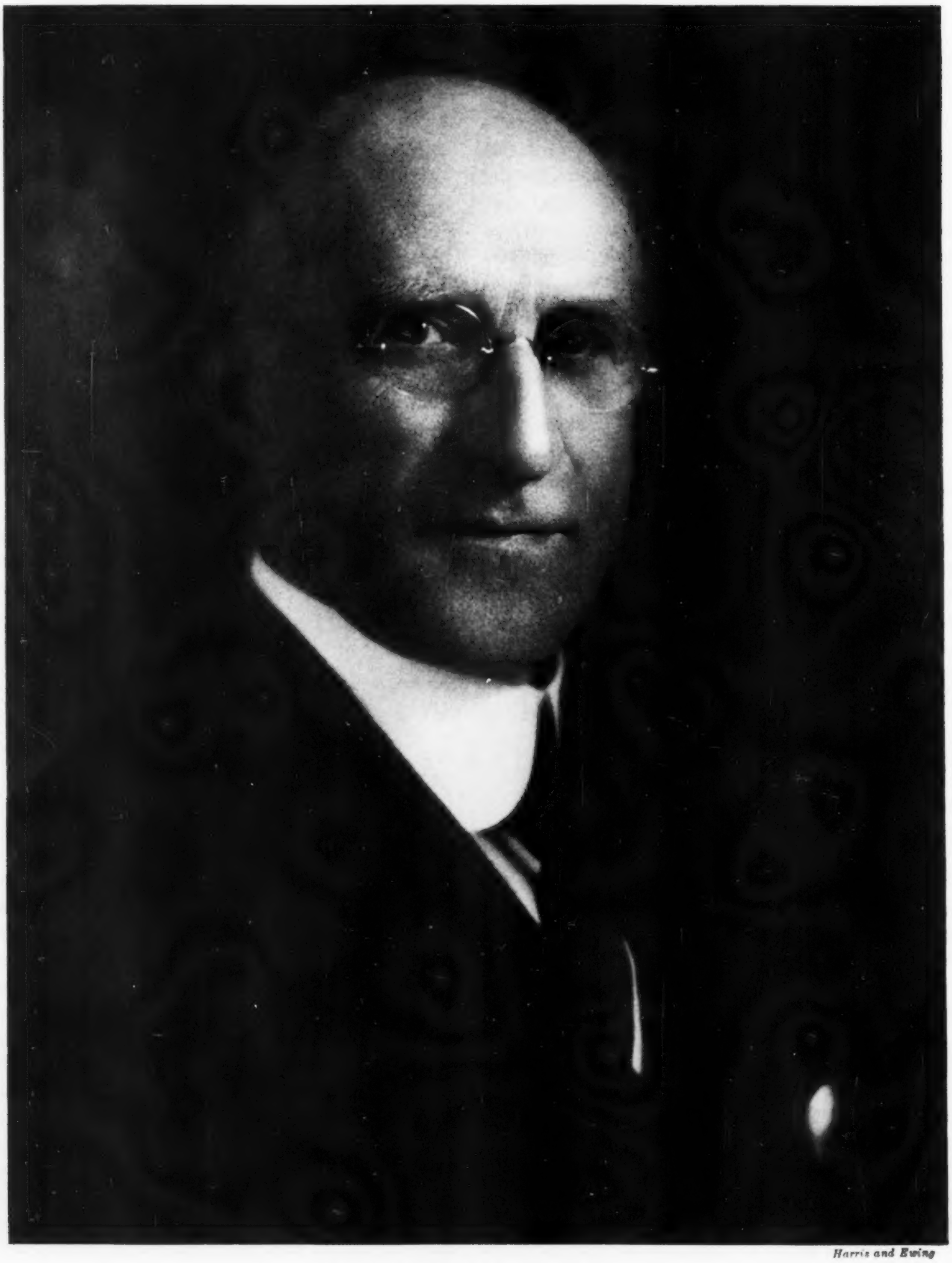
VIRGIL JORDAN, economist for the McGraw-Hill Publishing Co., has a wide following in readers of *The Business Week.* Orthodox as an economist to the extent that he does not always agree with others of his profession, he speaks his mind according to his beliefs. His beliefs are not always conventional, nor would they always become a Pollyanna. They are sincere and provocative. If you do not like what he has to say about our banks and bankers, for example, you are at liberty to disagree with him. If you think he has hit the nail on the head, you will find plenty of ammunition in his address at the Stabilization Symposium of the A.S.M.E. Annual Meeting, printed in this issue, to use in your next verbal encounter with those who know how the country should be run.

AFTER reading Dean Donham's and Virgil Jordan's addresses, turn to the account of the A.S.M.E. Annual Meeting where the other two papers at the Stabilization Symposium are briefly summarized, and see if you do not agree with us that engineers are beginning to show the interest in economics that Dr. Wright exhorts them to acquire.

CERTAIN factors of business stabilization were referred to by Virgil Jordan as being summed up in the concepts of security and freedom. These concepts fell, he said, within the field of the psychologist and psychoanalyst, and had therefore been generally ignored by the economist. Perhaps the engineer has given more thought to the significance of these concepts, but psychology has received scant attention at engineering meetings. This year, at the A.S.M.E. Annual Meeting, the Robert Henry Thurston lecture on the relation between science and engineering was delivered by Edward L. Thorndike, Professor of Education, Teachers College, Columbia University. Professor Thorndike's lecture appears in full in this issue.

FEARING that we might be accused of publishing an economic rather than an engineering journal, we slipped two engineering papers into this issue as a proper leaven of professional interest. One of them follows up an article on New York's new Eighth Avenue subway, published in the November issue, with a description of the cars to be used. The other is an attempt to show what the steel industry has been doing during the depression, special reference being made to the South Chicago works of the Illinois Steel Company.

BITUMINOUS coal held the center of the stage at Pittsburgh last November when scientists and engineers from all over the world met at the Carnegie Institute of Technology to discuss some of the technological and economic problems in connection with it. With so much depending upon the coal industry, engineers are particularly interested in its program and well-being. A report covering the principal papers read appears in this issue.



Harris and Ewing

Calvin Winsor Rice

CALVIN WINSOR RICE

His Work in Professional-Society Organization

By KARL T. COMPTON[1]

I DEEM it a great privilege to take part in this tribute to Dr. Calvin W. Rice. There are many others who could speak more eloquently than I, and who are better qualified than I to speak through having worked shoulder to shoulder with Dr. Rice on various phases of his activities during the past twenty-five years. Yet I am glad for the privilege because it is the Institution which I represent which gave Dr. Rice his collegiate education in engineering and which he now serves as an active member of its Corporation.

The other day the great airship *Akron* came sailing over Boston—a beautiful sight, with graceful, simple lines and calm, majestic flight. I could not help but think how little the ordinary man realizes how much of mankind's best thought and work lie behind that serene, smoothly running vessel. Think of the discovery of helium and the remarkable development of its production on a large scale; think of the perfection of rubber fabric and of the research which has gone into the production and studies of strong light alloys; think of the long development of heat engines; think of the conflicting theories that men have argued over, beginning with caloric and phlogiston and coming right down to theories of fatigue and plastic flow of metals—all related to the operation of the airship; think of the meteorological studies and the development of aircraft instruments! Little does the ordinary man realize what has gone on behind the scenes to make possible the great airship!

Similarly I think of the A.S.M.E.—a great, smoothly running machine. How little does the average member, and still less the non-member, realize what countless hours of planning, of work, of discouragement, and of achievement have been spent in creating the organization that we have today! And at the very center of this creative work during the past twenty-five years has been the man whom we have met to honor tonight.

I am going to give you a very brief sketch of Dr. Rice's work for the A.S.M.E. A knowledge of this work cannot but give you, as it gave me, a better appreciation of him and of the Society which he has so effectively served. Unfortunately I have not been an eye-witness of most of the events in the narrative, so that I have had to rely largely on published records and on testimony of Dr. Rice's colleagues for the information. I feel, therefore, that I should both preface and conclude my remarks after the manner of a certain preacher.

Newly called to a city pulpit, with the reputation of being an excellent pastor but a poor preacher, he agreeably surprised his congregation by preaching one splendid sermon after another. But one thing puzzled his listeners: he always prefaced each sermon by raising his hands high to the left, and concluded it by similarly raising them, but to the right. When he was finally asked what these gestures signified, he replied, "Oh, those are the quotation marks."

Dr. Rice was born at Winchester, Massachusetts, on November 4, 1868. After attending public schools in Boston, New Haven, and Winchester, he spent four years as a student in the Massachusetts Institute of Technology, from which he was graduated in 1890 with the B.S. degree in electrical engineering. He then held successively positions as assistant engineer in the Power and Mining Department of the Thomson-Houston Company in Lynn; as engineer in the General Electric Company in Schenectady; district engineer for that company in Cincinnati; engineer with the Silver Lake Mines in Colorado; consulting engineer for the Anaconda Copper Mining Company in Anaconda, Montana; electrical engineer of the Kings County Electric Light and Power Company, and later with the New York Edison Company and the Consolidated Subway Company; vice-president of the Nernst Lamp Company; and consulting engineer with the General Electric Company at New York. It was from this rich and varied experience in electrical, hydraulic, and steam engineering, combined with managerial and executive work, that Dr. Rice was called to the secretaryship of the A.S.M.E. in 1906.

TWO OF DR. RICE'S GREAT SERVICES TO ORGANIZED ENGINEERING SOCIETIES

It was even before 1906 that Dr. Rice performed two of his great services to organized engineering societies in America. He joined the A.I.E.E. in 1897 and the A.S.M.E. in 1900. Almost immediately he, with others, participated in the first cooperative project of the four great national engineering societies, namely, the establishment of the John Fritz Medal. He was then serving on the Society's Committee on Meetings.

In 1902, as Chairman of the Building Committee of the A.I.E.E., he called a dinner meeting of the committee, together with the president of the A.I.E.E., Prof. Charles F. Scott, and several others, to discuss plans for a modest building for the Institute primarily to house the Latimer Clark Library, which had been presented to the Institute by Dr. S. S. Wheeler on the

[1] President, Massachusetts Institute of Technology, Cambridge, Mass.

Address at the Annual Dinner of the A.S.M.E., Hotel Astor, New York, Wednesday, December 2, 1931, preliminary to the presentation of Honorary Membership in the Society to Dr. Rice.

condition that a fireproof building be secured to house it. The Committee had, at that time, definite prospects of only about $250,000. When President Scott suggested that consideration be given to the possibility of a building for housing the four National Engineering Societies, with a common library and a common auditorium and individual rooms for the headquarters of each society, doubts were expressed as to whether the four societies could be brought into such a cooperative project.

Strenuous efforts, which were at the last minute successful, were made to get Mr. Andrew Carnegie as a guest at the next annual dinner of the Institute. At this dinner President Scott outlined his ambitious plan and pointed out its fine features—including the library.

The next day Mr. Carnegie asked Dr. Rice to come to his residence at five o'clock, and Dr. Rice, with characteristic thoughtfulness of others, as well as admiration for the lofty character of his president, brought with him Professor Scott. There Mr. Carnegie asked them further about the work of the Institute, about the finances of the engineering societies, about the relation of the proposed building to the Engineers' Club (of which he was a member). Dr. Rice cleverly inferred that an obstacle in Mr. Carnegie's mind was the securing of the land, for the latter was not in the habit of buying the land on which the libraries which he donated were built. Dr. Rice then optimistically remarked that the Engineering Societies would be able to provide the land, whereupon Mr. Carnegie gave a cheerful smile and said, "If you can provide the land, I will put up the building." Dr. Rice was made chairman of the building fund.

Then the money had to be raised to buy the land; complications and difficulties in perfecting the organization and developing the plans had to be overcome. In the words of Professor Scott, "Mr. Rice's devotion to the idea of a building for the Institute and his skill in directing the early conference with Mr. Carnegie and his enthusiastic and faithful assistance in subsequent service to the Institute in carrying out the project were fundamental factors in the creation of the Engineering Societies Building and the separate building for the Engineers' Club."

INTERNATIONAL CONTACTS ESTABLISHED BY DR. RICE

It is of course impossible in this short summary to enumerate more than a few of the incidents to illustrate Dr. Rice's method and the international contacts he has established.

In 1901 when Marconi first succeeded in receiving signals across the Atlantic by radio and Dr. Rice was satisfied that they had actually been received, he proposed public recognition of the inventor by means of a banquet. At first he met with opposition, but he persevered until he obtained the willingness of two outstanding men of science to express their confidence by attending as guests of honor, and with this assurance a successful dinner was held.

In 1902 Dr. Rice proposed, and was made chairman of, a committee to arrange a reception for Lord and Lady Kelvin. As he tries uniformly to secure a cooperative undertaking, always thinking in terms of the object to be attained rather than of the credit for the undertaking, Dr. Rice secured joint patronage for this event from the National Academy of Sciences, the New York Academy of Sciences, and the four national engineering societies. The reception took place in the gymnasium of Columbia University, and more than two thousand attended.

Contacts with foreign engineering societies began in 1897, when Dr. Rice obtained much valuable information from two especially able secretaries—James Forrest, of the Institution of Civil Engineers, and Dr. T. H. Peters, of the Verein deutscher Ingenieure. Later, in 1904, he was assistant chairman of a committee to arrange a circular tour of the United States by the Institution of Electrical Engineers.

In 1910 Dr. Rice had a most unique experience, an account of which has never before been published. That year the A.S.M.E. made a return visit to the Institution of Mechanical Engineers at their Birmingham meeting. Remembering that in a modest way the A.S.M.E. had contributed to the memorial window in Westminster Abbey to Sir Benjamin Baker, Honorary Member, A.S.M.E., Dr. Rice wrote to the Dean asking if it would be permissible for the members of the A.S.M.E. when passing through London on a certain Sunday, to visit the Abbey and view the window. Not only was permission granted but a special service was arranged, with a sermon on engineering by the Bishop of Lewes, and on this occasion the "Hallelujah Chorus" was rendered by the full surpliced choir. The event was further made memorable by having the A.S.M.E. audience arranged in a semicircle about the memorial window, the movable pulpit having been placed beside it.

Dr. Rice noticed that every window in the entire Abbey, save one, was a memorial window. The unappropriated window was apparently an original plain-glass window and was very dull by comparison. The next day Dr. Rice called on the Dean to express gratitude, and in conversation commented on the unoccupied window. The Dean immediately responded that the Abbey would appreciate a gift of a memorial window. Dr. Rice thereupon sensed the situation and offered a window, knowing it would be an easy matter to collect from the entire English-speaking world an amount sufficient to install a window to an engineer.

Among Dr. Rice's souvenirs is a letter from the Dean of the Abbey agreeing to accept such a window.

Dr. Rice proposed a window to his friend Lord Kelvin as one mutually desired by the Abbey and by engineers. Consistently he arranged that this memorial be provided through the cooperation of the engineering bodies of Great Britain and the United States. Having obtained instant approval of influential persons in England, he used the same method in the United States and, when the undertaking was assured, placed the whole proposition in the hands of the Institution of Civil Engineers, the oldest and most important engineering organization in the world, for announcement of the popular subscription.

The result was so successful that not only was the window provided but the Kelvin Medal was founded. This is probably the only joint undertaking of this nature by the English-speaking world.

In 1911 when Dr. Rice, who previously had frequently visited the Deutsches Museum and become acquainted with its Director, Dr. Oskar von Miller, learned that a mission from the Museum was to visit the United States to inspect technical museums, he obtained permission from the officers of the A.S.M.E. to offer by wireless the services of the Society in arranging a suitable itinerary. Through local committees Dr. Rice arranged receptions by Columbia University, Mr. Schiff, Mr. Carnegie, President Lowell of Harvard, Chicago University, and at Washington and Philadelphia. As a result the entire Society was invited by the Verein deutscher Ingenieure to visit Germany in 1913, Dr. von Miller at that time being both president of the V.D.I. and director of the Deutsches Museum. Upon acceptance of this invitation Dr. Conrad Matschoss spent six months in the United States visiting the principal sections and working up the details of the visit. Three hundred and sixty went to Germany from this country, chartering the remodeled S.S. *Deutschland*, renamed the *Victoria Louise*, for the trip.

ESSENTIAL PERSONAL QUALIFICATIONS AND PRINCIPLES EXEMPLIFIED IN DR. RICE'S WORK

These early activities of Dr. Rice's exemplify some of those personal characteristics and adherence to those principles which seem to me the essential qualifications for a successful leader in any professional-society organization.

As personal characteristics I would list in order:

1 Ability and desire to cooperate with others
2 Ability and judgment to recognize a good project when it is suggested
3 Initiative and drive to carry a project through to completion, and
4 Daring to undertake an audacious project, once convinced of its merit.

As principles underlying society organization and operation I would list:

1 Unselfish cooperation with other related societies
2 Planning actively for the future, so that development may not be haphazard, and so that opportunities for development in the desired direction may be quickly and firmly grasped when they present themselves.

All of these qualities and principles you will see strikingly evident in the two examples I have given—the John Fritz Medal and the Engineering Societies Building.

But there are still other essential personal qualifications and principles, all of which are exemplified in other phases of Dr. Rice's work, which I should like to list and then briefly discuss.

Additional necessary personal qualifications are:

5 Originality of thought.

Dr. Rice gave a striking example of this when in 1902 he first suggested to the Chief of Staff of the U. S. Army a plan for forming the Officers' Reserve Corps and the R.O.T.C., later worked out by Dr. Rice with General Wood when Commander of the Department of the East, and by a joint committee of the Engineering Societies under the chairmanship of General Barclay Parsons.

6 Ability to organize, to delegate authority to others, and to spur others on to take active part in the affairs of the society.

These attributes of Dr. Rice are strikingly illustrated by the remarkable committee activity of the A.S.M.E., with its active committees on publications, on meetings, on research, on standards and codes, on professional ethics, etc. They are also strikingly shown by the sectional branches of the Society, both on a subject basis and on a geographical basis.

One interesting corollary of this ability to organize is fundamental unselfishness. No man who is fundamentally selfish can occupy the key position in an active, smoothly running, and progressive organization. President Lowell of Harvard once said to me, while discussing the philosophy of administration, "No man can accomplish any great thing and get the credit for it at the same time. If he strives for both, the chances are greatly against his achieving either."

Additional principles of successful society organization appear to me to be the two following, and these are the most fundamental of all. I think they are equally important.

3 The first objective must be to give the most effective service to the members of the profession
4 The second objective must be to lead the profession in rendering the most valuable possible service to society.

In these two statements there is much food for thought. I would call attention to only a few implications.

To give effective service to members of the profession, the society must give them what they want, and this involves many things. It must give them helpful information. It must give them opportunity for self-expression, whether this be through publications, conferences, organization and administration, or otherwise. It must skilfully arrange so that the most progressive ideas of the best leaders quickly and spontaneously become the objective of the main group.

TWO OPPOSING PHILOSOPHIES OF SOCIETY ORGANIZATION

There are two opposing philosophies of society organization on this point. One is the autocratic philosophy, which involves the direct control of the membership, for their own good, by an individual or small clique of supermen sitting in the seats of authority. In favor of this we may point out the probable consistency of program, the wisdom of decisions, and lack of confusion of ideals and operations.

The other philosophy of organization is the democratic one. Its ideal, as I see it, is to give every member the maximum individual opportunity for contributing to the progress of the profession and the welfare of the society. Its advantages are that it tends most rapidly to develop the individuals and to create in them a live interest in the purposes of the society, and that the sum total of the valuable contributions by the members is likely far to exceed those simply of a chosen few.

Time and time again experience has shown the relative defects of the autocratic system. It is not sufficiently sensitive to changes—to the march of progress; it deadens rather than quickens the interest and activity of the membership; it frequently runs into rebellion and secession by active groups who chafe with the urge for individual activity. In my judgment, any society whose leaders gain the feeling that wisdom is implanted in them alone, and that they must exercise it for the benefit of the common herd, is in for either a slow or a violent death.

THE A.S.M.E. AN OUTSTANDING EXAMPLE OF THE DEMOCRATIC PHILOSOPHY OF ORGANIZATION

The A.S.M.E., on the other hand, is the outstanding example of the democratic philosophy of organization. With almost ten per cent of its members serving on active committees, no other society of which I know can surpass it in the effectiveness of its *esprit de corps*, its development of leaders, its rapid improvement in the standard and status of the profession, and its helpfulness to its individual members.

Coming finally to the last objective, that of rendering service to society, I would simply affirm my belief that the right of any organization to public recognition and support, and even its right to exist in this overcrowded planet of ours, is measured entirely by its service to society. You have a right to your organization, you have a right to your own existence, you have a right to the profits (if any) of your work, in the last analysis, only because society needs mechanical engineering and mechanical engineers. Our enthusiasm for the profession is due to the fact that we believe that still more and better engineers will be needed in the future, and that the engineer, if properly skilled in his art and at the same time responsive to the social and material needs of the public, can make an even greater contribution to public welfare than he has made in the past.

It is a sign of strength in the A.S.M.E. that the Society has so clearly recognized the social responsibility of the engineer. It has sought to express this responsibility in a code or motto. It has actively expressed it through its work in standardization and construction codes. It has exemplified it by itself behaving like a social being through cooperation with other related bodies both national and international.

Finally, permit me to say that the A.S.M.E. has been a great leader in working out a constructive, effective plan of society organization, and to say that the man whom we honor tonight is putting the genius of a great life's work into developing this organization for the direct service of its 20,000 members and the direct service also of the nation and the world.

And now, Dr. Rice, an authority has said that the greatest satisfaction of life is the realization of duty well done. On this twenty-fifth anniversary of your undertaking the secretaryship of this Society, that satisfaction is yours. We wish you many happy returns of the day.

Mechanical Aspects of Electricity

THE question of what lay behind the exercise of mechanical forces between electrons themselves or between electrons and positive ions was akin to what caused the mechanical attraction called gravitation. It would appear that while the electron had made easier the conception of what went on in material bodies, it had also made it more difficult to conceive what happened in the electric or electromagnetic field in a vacuum. Mathematical physicists had at present abandoned the attempt to give a mechanistic interpretation of what lay behind the phenomena of attractions and repulsions, and the purely mathematical treatment which employed symbols conveying no physical meaning must appear very nebulous to the mechanical engineer. To the engineer there seemed to be no escape from the fact that the actions discussed involved the interchange between visible motion and invisible motion. Potential energy in a raised mass was a fact, but no mental conception could be had of anything having happened except that some invisible motion remained in the space between the earth and the body, which would cease when motion was again given to the mass as it fell to the ground. So, when electrons were removed from positive ions by mechanical motion, it seemed that there must be some motion somewhere as the equivalent, representing the mechanical work, which would reappear from the surrounding field when it collapsed by the return of the electron to the atom to which it belonged. The fact that proof had been obtained that magnetic fields were due to electron rotations premised again rotational energy as the form of energy hidden from sight but, nevertheless, existing and which could presently be recovered from the magnetic field. These ideas might in some way incorporate themselves in the explanations which would emerge in the future.—From report in *Engineering*, Nov. 13, 1931, of lecture by Llewelyn B. Atkinson, F.K.C., before the Institution of Mechanical Engineers.

TWENTY-YEAR PLANS

As Related to the Temporary Emergency

By W. B. DONHAM[1]

W. B. DONHAM

I PREPARED two addresses for this occasion. Needless to say I shall inflict on you only one. Even that is so long that I shall ask leave to extend in print. The first address which I planned was based on an effort to survey the changing circumstance of our complex world and to evolve methods by which intelligence might be substituted for blind chance. The variables seem at first sight so numerous that they are wholly beyond human capacity for thought. I attempted to reduce them to manageable proportions. When this approach was 90 per cent completed, my attention came to be focused on the experience of nature in working out similar problems by the slow processes of organic evolution. I reexplored the same situation from this angle. To my surprise the results reached by these differing modes of attack were wholly consistent and substantially identical. This is of course not a real check on the thesis. Nevertheless natural processes have a way of sorting out the irrelevant and attacking the essentials. I shall give you today the results of that study of nature's methods.

EMERGENCY RELIEF MUST NOT HINDER FUTURE

The old legal maxim, "Hard cases make bad laws," will apply, if we do not watch our step, to our economic and social situation. The natural reaction of all sympathetic persons to the present critical situation is to cure it by any possible means, regardless of consequences. Plainly it should be dealt with boldly, and some sacrifice of the future may be inevitable. So far as we can think things through, such sacrifice should be neither unconscious nor thoughtless. It is more important to prevent the recurrence of conditions like the present than it is to better slightly our method of dealing with the distress. So far as our capacity to organize is capable of handling such problems, we shall not allow men to starve or to go unclothed or unhoused. It is too late to preserve for this occasion the self-respect of a host of our countrymen who are forced to live on charity. The processes of relief should contribute to, rather than hinder, those constructive modifications of our social organism which must prevent similar sufferings and similar loss of self-respect in the future.

There is, I believe, no room for doubt that the great mass of our people desire, not radical or revolutionary changes in our social organism, but the continuance of our present system of private capital and individual opportunity. In their present mood, however, they will favor almost any change which seems to offer present security. Under such conditions there may be too little critical study. Collateral results of changes made in efforts to obtain security may stifle initiative. Modifications in our present system are inevitable, for it has shown grave inability to cope with its fundamental problems. Such changes should not be allowed to happen without an effort on our part to get a wide and clear vision of the needs of the future, as well as of the present. It behooves us, before we act, to study carefully the adaptation of remedies, plans, and systems to our democracy and to private capitalism. Failure to do this will be dangerous.

Many immediate problems will press on the new Congress, and numerous schemes will be suggested with strong backing. Federal doles, under other names, will be advocated, and might indeed in some form be wise. Government control of private enterprise through one or another scheme will certainly be suggested. Great bureaucracies of one type or another will be proposed. There is grave danger that our view of things will be all foreground, without background or perspective. Even the most thoughtful of us may be so oppressed with the

[1] Dean, Graduate School of Business Administration, Harvard University, Boston, Mass.

Fourth Henry Robinson Towne Lecture on the Relation Between Engineering and Economics. Delivered at the Annual Meeting, New York, November 30 to December 4, 1931, of The American Society of Mechanical Engineers.

present distress that we forget the cool appraisal of the future and its values.

It is not my primary purpose to discuss remedies for present conditions. Rather I desire to suggest some basic reasons why our industrial civilization faces constantly recurring and increasingly serious conditions of insecurity, and to draw certain analogies from the well-established processes of organic evolution which appear pertinent to the situation now faced by our social organism. From such an analysis we may work out a better understanding of our objectives—an understanding which may be useful in considering specific remedies for the present and plans for the future.

INSECURITY DESTROYS INDIVIDUAL OPPORTUNITY

Every scheme for the organization of society is an oversimplification. It is impossible to adjust the small number of basic conceptions which must be the foundations of any society to the varying needs and opportunities of 125,000,000 individuals. Broad slashes are necessary. By the accident of its historic development our present society in the economic area favors individual initiative and opportunity at the expense of security. The chaos such individualism creates in times of depression is obvious. Miscellaneous, haphazard efforts to remedy the present situation will be of little value in preventing the recurrence of such situations. This is no time to adopt as our motto,

"Do all that you know and try all that you don't.
Not a chance must be wasted today!"

Our social organism deals so inadequately with problems of security that at the present moment it reacts on itself, taking away individual opportunity and the chance for private initiative. Yet we should not lightly give up the advantages of individualism. Nor can we remove all risks. Individual opportunity and initiative must necessarily carry with them individual risk of failure, and no one who tries to be a leader can avoid these risks. Risk goes with opportunity. The difficulty is that under present conditions the risk is borne not alone by the individual who through his own initiative seeks personal opportunity. Many others suffer with him.

It is wrong that the risks of those who are seeking opportunity should be shared in full measure by millions of men who never wanted to take risks and sought no opportunity except to work. These millions are powerless to affect the situation, even to understand its implications. They are in no sense responsible for the condition, and their primary desire and primary right to such extent as human rights can exist is the right to work for a living. During the last decade when the table was being set for an orgy of unemployment they were wholly unconscious of what was happening.

THE WORKMAN'S STAKE IN INDUSTRY

The stake of the ordinary workman in the success of our industrial civilization is great. Never in history has there existed such a fluid condition in society, never have general standards of living been so high. If we could give reasonable assurance of continuity of employment, a comparison of the lot of our laborer with that of the peasant farmer the world over would be all in favor of our group. The oft-criticized monotony of work at machines never approximated the dawn-till-dark monotony of work on the unmechanized farm in China or India or in the England of a hundred and fifty years ago. Material possessions and leisure have never been so common, nor opportunities for their enjoyment, yet with all that we have, with all that industry means to us, it is probably true that this country and the western world generally have not in hundreds of years been so unstable and so insecure, so far as the necessities of life are concerned, for the mass of people as they are now.

CONTINUED INSECURITY THREATENS PRIVATE CAPITALISM

The Russian social experiment seeks an oversimplification in the direction of security for the individual, but this is sought at the expense of individual initiative, personal opportunity, and, from our standpoint, of self-respect. Russia may well attain security on a large scale, in fact has made progress toward it. They have no unemployment, but the security is accompanied by a low standard of living. Perhaps we might stay on a higher plane anyway, but even moderate wisdom can, I believe, keep our standards on a higher basis. The principal justification for private capitalism is that more rapid social progress may be attained under private capitalism than under socialism or sovietism, and that all large groups can share in that progress. But progress requires stability as well as change. Private capitalism must afford a greater degree of security or it will fail not only to progress but to maintain itself. There is no possibility of standing still. Unless we soon give greater security, we shall lose the chance to seek higher living standards and continuing progress under private capitalism.

The world is too complex, the rapidity of communication too great, the tempo of change too rapid, for civilization to endure by the continuance of our present methods. Our social organism must exist in the midst of appalling complexities and of exceedingly rapid change. Everything is in a state of flux. Where many interrelated factors are in flux, thinking by logical processes becomes impossible. We are left at the mercy of chance, and the social organism is itself so unstable that we are in a state of economic chaos.

SCIENCE CHANGING THE WORLD

The time elements of change no longer run to centuries. The last fifty years have changed the environment of the ordinary individual more than the preceding nineteen hundred and thirty years. We cannot by constant thought keep up with the new conditions. On the other hand, we should not leave the future of society wholly to chance. Methods should be devised not for dealing with successive specific changes in our environment, but for adapting human society to continuous and reasonably stable life in the midst of change. Science and technology are responsible for the new time elements.

You gentlemen have a great share in this responsibility. Yet the problem cannot be met by a moratorium on science. Nor can we stop you in your progress. If for no other reason, such a moratorium would be too late. We are now struggling with the delayed consequences of mechanical inventions a hundred years old, and we have not yet learned how to adapt ourselves to the changes so originating.

Science and technology if they can be tamed will constantly offer greater opportunity not only to business but to all groups in society by steadily making human labor more effective. The conflict between change with its attendant opportunity and risks, and stability with its reduced risks may be adjusted and the essential stability maintained.

Problems of war and peace, of international trade and credit, of international debts, of domestic credit, of unemployment, of prosperity and depression, all become so complicated by the new time factors of change, and by the multiplicity of the changes taking place at all times, that wise and effective modes of handling specific changes can rarely, and then only by accident, emerge from the welter of things.

Yet we constantly try to keep up with this overwhelming flux by the process of understanding its successive stages, and then to work out fixed modes of dealing with each specific change. The theoretical study of society under these conditions too often becomes an effort to examine isolated bits of this whirlpool in the vain hope that some day we may understand the elements of the problem well enough to control causes and bend the future something to our heart's desire. The task so conceived is hopeless. The limits on foresight are too great and the limits on action based on foresight too pronounced to enable us to plan wise programs and translate them into action within the necessary time limits.

IMPOSSIBILITY OF KEEPING STABILITY BY PRESENT METHODS

The task of maintaining essential security in our social organism by this mode of attack is hopeless politically, because no one short of a tyrant can even theoretically act fast enough to handle the problems tumbling over each other for attention. It is hopeless intellectually, because no one short of the Deity Himself could secure the facts necessary to understanding and draw the essential conclusions in time to act. No refinement of the superstructure of thought and theory will give the basis we need for dealing wisely and within the necessary time limits with the individual changes in our environment. Yet we must prevent these changes from disturbing the fundamental social stability out of which sound evolutionary progress of society alone may evolve. Our philosophical problem cannot be that of outthinking change on its own grounds. We must remove great areas of the problem to a setting of our own choosing. The problem must be defined as the problem of keeping adequate stability in our society in spite of an environment which changes at constantly accelerating speed.

The chemists know a group of chemical reactions which they designate as autocatalytic. Their common characteristic is that each contains within itself the capacity for generating substances which bring about constantly accelerating chemical change. A common consequence of such reaction is violent explosion. The analogy is apt. If we do not so handle the changes brought about by technological and scientific progress that they no longer place constantly increasing strains on our social structure itself through unemployment, violent depressions, and international strife, these changes will destroy the social organism.

SOCIETY A LIVING ORGANISM

Now our society is not a dead thing. Just as certainly it is radically different from an aggregate of the human beings of which it is composed. If we are to understand it at all, it will be as a living, moving, growing organism, facing the same types of problems that biological organisms have faced for vast periods of time. The analogy is apt. The problem of biological survival has always been the problem of adjustment to environment. Simple organisms worked out a few simple adjustments to thoroughly established static conditions of environment. Other organisms as they reached out to conquer new and rapidly changing environments, either developed complex social adaptations as in the case of the ants, or exceedingly complex individual as well as social adaptations as with mankind. The trouble with our present situation lies in the fact that our social adaptations were still far from perfectly worked out in an environment where the significant time elements involved in significant change ran to hundreds of years. Such time elements are now less than a generation. Naturally enough, with the old time elements the slow-moving forces of evolution failed to develop in the social organism adequate methods of dealing with rapid change. We are concerned with a problem where the ordinary processes of evolution have not had time to operate.

SOCIETY MUST ADAPT ITSELF TO CHANGING ENVIRONMENT

The individual human organism is wonderfully adapted to change. We can adjust ourselves to extremes of heat and of cold, to the mountain side or to deep mines, to humidity or to excessive dryness, to hard physical work or to intense intellectual effort. Our marvelous capacity for dealing with change is well illustrated by the rapid adaptation of millions of men to the modern automobile and of thousands to the new airplane. It is of the essence of survival of the complex animal organism that it must adjust itself to the exigencies of unforeseeable changes in environment. Our social organism must develop the same capacities. Over a time span of 50,000 years it certainly will, or the human race will cease to dominate the earth. But must we wait for the slow-moving forces of biological evolution to solve this problem? On our basic assumption that society can only be understood as a living organism, may we not bring to bear on the problem the free intelligence which is our heritage as human beings and use the power thus given us to accelerate the slow-moving

forces of organic evolution? The problem is defined. It is the problem of introducing into our American industrialized social organism methods of dealing with change without loss of fundamental economic and consequently social stability. We are surrounded by, and we ourselves are, organisms which through the long eras of biological evolution have solved exactly similar problems.

METHODS USED BY ANIMAL ORGANISMS TO MAKE ADJUSTMENTS TO ENVIRONMENT

To me as a layman, organic evolution appears to have developed at least four important methods of dealing with this difficulty upon which organic survival of both individuals and species depends. I shall not describe them in the technical language of the biologist, nor shall I follow biological classifications, though I rely for part of my material on the published papers of my distinguished colleague in physiology, Professor Walter B. Cannon. These four methods of solving the problem are:

I—*Permanent Adaptation to Persistent and Stable Changes in Environment*. The whole sweep of organic evolution illustrates this process. In their broadest aspects many of our present social and economic difficulties are steps in the process of adapting our social organism to a machine age. Every industrial nation faces the necessity of making far-reaching and long-time adjustments to meet the developing characteristics of this still new industrial environment.

II—*Insulation and Defense*. There are many instances of biological insulation from environment. The dead cells of the skin, the wool of the sheep, the shell of the turtle will serve as examples. In the economic world the army, navy, and the tariff insulate the national organism from its environment and are cases in point.

III—*Compensating Mechanisms*. The human body is able to exist in the changing conditions of its complex environment because it has developed many compensatory mechanisms, all in their processes of operation bringing about minor changes within the organism which enable it to maintain its fundamental stability. Thus fundamental stability becomes dependent on capacity for minor changes which compensate changes in environment. The adjustments so made are to an overwhelming extent automatic. Conscious processes of thinking play little part in the picture. Moreover, the adjustments so made deal not only with external changes like temperature, humidity, food, and the like—the foreign relations of the body, but a great variety of devices has been developed for dealing with internal adjustments required by changes in the internal environment of the body, its temperature, its blood sugar, its supply of fats and proteins—the domestic affairs of the organism. These adjusting mechanisms are automatic and only to a limited degree subject to intellectual control either by the individual or his physician. Nature has never shown any interest in the causes of the changes in environment.

The point I am emphasizing here is the extraordinary development in complicated animal organisms of mechanisms prepared in advance, not for dealing with the causes of change, but for absorbing automatically the shocks of change and adjusting the organism to such changes when they occur so that they do not disturb its fundamental stability. The mechanisms work because the occasions arise which bring them into action. They do not wait until each event is analyzed with great care by complicated research agencies and until action can be taken on the foundation of reasoned decisions. The event, in itself generally uncontrollable, stimulates the automatic response which is necessary to maintain stability. We have in the economic field many illustrations of such automatic mechanisms. Much of economic theory deals with them. Demand and supply, the forces governing international trade, movements of credit are all illustrations. We need far more such automatic devices.

IN my judgment we should set up a general thinking body, an Economic General Staff, with no control or espionage power, containing men chosen by representatives of the Government, of industry, and of labor. The most important job of this Economic General Staff should be to study the principal shocks to which society is subject and to recommend elastic institutions or programs which will meet these shocks as nearly automatically and with as little delay as possible whenever they occur from any series of causes. Such a body would be futile or dangerous if given control. Espionage powers given to such a body would be unfortunate, for they would through the development of fear prevent the growth of influence. This Economic General Staff should include a business research and interpretative division constantly studying general business problems and interpreting them. The function of such a division should be to give intelligent bases for business decisions.

IV—*Decisions Based on Thinking*. We esteem ourselves different from other animal organisms mainly because of our greater capacity to think. Yet it is obvious that this capacity for thought could not have developed if in the process of evolution nature had decided to make all action and all internal and external adjustments dependent on conscious volition. One price paid for the development of free thought was the settlement of most matters by automatic processes rather than by processes of thought.

Even where conscious exercise of the will is the basis of adjustments to environment, the ability to create habits comes to our aid and removes other large groups of questions from active volition. We step out of the way of automobiles because we have thought out the problem so many times that we don't need further thought as the foundation for action. The world within which the individual organism lives would be far too complex for continued existence on any other terms. Our brains serve as the basis for individual progress because most problems faced by the individual are solved automatically.

SIMILARITY OF PROBLEMS FACED BY ANIMAL ORGANISMS AND BY SOCIETY

Can we learn anything from these biological analogies? I believe so. As a social organism we face strangely similar situations. We must face the increasing complexity of the world, the difficulty of securing and appraising facts, increasing instability the world over, our lack of control over the causes of our troubles, the limits on our understanding proceeding not only from limits of knowledge, but from the complexity of variables which in most fields limits thought itself. We can have little better understanding of or control over the forces at work at any moment than the human mind has of the constant flux of chemical reactions which bring about the automatic adjustments which alone make possible the organic stability of the individual.

But I repeat that our task is not the impossible one of comprehending wisely and acting understandingly with reference to all major elements in the constant flux of new problems. It is the task of observing the social consequences flowing from a mass of events which is and always will be for any period or episode beyond human understanding or control, picking out those results which critically unstabilize society and counteracting them. Our legislation, our efforts at central planning, our best thought should be directed not at vain efforts to account for or to deal with conditions current at any particular period, but at bettering our adaptation to our environment. Mechanisms are needed which will, when the occasion arises for their use, automatically, or as nearly as may be, absorb the shocks. When this is accomplished a field will have been separated out where planned intelligence may relate itself more to progress and less to stability.

THE search for remedies is more important than the search for causes, though as in medical science a knowledge of causes will often aid in discovering remedies. Even where we have a theoretical understanding of the causes of similar situations in the past, that understanding in itself may prevent action, for always the momentary forces at work are obscure and the weighting of the elements is so complex that those who should act waste their time in futile discussion. Happily the results flowing from these complex causes in so far as they critically unstabilize society, appear to do so in a few important ways. We must search out these ways and devise mechanisms adequate to counteract their effects. In so doing lies our opportunity of substituting organized intelligence for blind chance in our economic world. We must not forget that nature is impatient of failure. The past is full of the wreckage of species which failed to adapt themselves to their changing environment.

CHANGE AS WELL AS STABILITY NECESSARY

I have emphasized stability because substantial stability is essential to progress. But change also is essential, and change is in itself a part of our basic stability. Indeed, my whole thesis resolves itself into the question how we may maintain sufficient stability in the midst of the rush of change so that we may benefit from change itself and secure the increased stability which is in large measure dependent on scientific change. Our objective from the standpoint of change is to secure the maximum stimulus to individuals in bringing about changes which are consistent with the necessary stability. The human body is stable in the midst of changing environment, and apparently this stability has attained essential organic permanency over many thousands of years. Human thought was developed on the foundation of this stability, and the chance for the continued development both of individual opportunity and social intelligence in our social organism is dependent on similar relative stability.

METHODS OF ATTAINING SOCIAL ADAPTATION TO ENVIRONMENT

Our task of maintaining social stability by adaptation to environment is the five-fold task faced by every complex organism. Suggestions and plans may be tested by their fitness to help solve these problems.

No solution offered will be perfect. Since specific plans must meet the general needs of great groups, a few ideas of fundamental significance are needed. It is the primary obligation of government to furnish this essential stability, and to this end to create the necessary mechanisms of adjustment. It is the primary obligation of business to contribute through its efficiency to economic progress. I shall examine the tasks involved in some detail.

I *Durable Change In Environment*. How may we work out sound and secure adaptations to long-time changes or permanent characteristics in our environment? In this area relatively static solutions of the problems become possible, for conditions dealt with are relatively static.

EXAMPLES OF LONG-TIME ADJUSTMENTS NEEDED

Old age, disability, accidents, disease, and death are outstanding examples of situations obviously permanent in their incidence. All such situations impose great and badly distributed burdens on the social organism. Sound solutions of such problems can be relatively permanent in their nature. Insurance principles can be brought to bear. The costs involved are already borne by individuals or by charity, just as the costs of fires and shipwrecks were borne by individuals before insurance developed. Broad, comprehensive solutions of such problems by our society would contribute greatly to social stability. The answers to such problems can never, however, be given by industry except in limited areas where industry is itself responsible. These are phenomena of the internal environment of the social organism, and the responsibility for adaptation to these facts is broader than business. It is mainly a social responsibility to be met by government action.

At the present time we have a tendency to deal with short-time changes in our environment as if they were permanent and to attempt solutions by methods and legislative acts which are inelastic. This type of settle-

ment of problems of the future is exceedingly dangerous, some of our most troublesome difficulties originating in this way.

DANGERS OF TOO CLOSE INTERRELATIONSHIP WITH OTHER ECONOMIC GROUPS

II *Insulating Devices.* How may we build up, where necessary, conditions for the insulation or defense of our social organism against external environment? In a world as troubled with changes as are international relationships, not we alone but all great economic groups in the world will do well to study with care the possibility of improving such insulating devices as the tariff and perhaps of creating other similar devices. Much of the adaptation required under the previous heading will, in my opinion, be of this insulating and defensive variety. The instability of the foreign situation makes this in my judgment clear. I make this suggestion not out of narrow nationalism but from a deep-seated belief that the hopeful approach to international stability while the world is in process of industrialization, with all that industrialization implies, lies in the direction of reducing the points of possible friction among nations until they come within the understanding of our leaders. For this reason I regret the entry of this country during the last few years into the international markets as huge buyers of foreign securities, and should welcome steps to cancel the war debts on appropriate terms.

EXAMPLES OF DEFENSIVE ADJUSTMENTS

Most situations will require other types of remedy. I have mentioned the army, the navy, and the tariff as examples of this type of defensive mechanism; it is obvious that all devices under this category should be relative to the conditions faced. Biological history offers many examples of organic types which overdid both offensive and defensive devices and perished from the face of the earth. The difficulty of all such devices is that they stimulate similar competing activities and tend to start a vicious circle. It is the mobile animals which maintain capacity to deal rapidly with changing environment, rather than those which rely on defensive mechanisms, that have inherited the earth. Nevertheless all such devices should be considered both objectively and realistically with reference to other factors in the situation. So considered in their relations with time elements over which our generation has control, armies, navies, and tariffs are all, in my judgment, essential to our security.

I believe it demonstrable that this episode of economic distress is not merely a business cycle but that it involves far-reaching and persistent changes requiring a reappraisal of the effects of the industrial revolution in the world. In my judgment the industrialized nations of the world must look anew at their relationship to the rest of the world and, either by conscious effort or through the unplanned results of the many forces at work, reach new adjustments in their national economies. The methods to be adopted in dealing with these far-reaching changes are not clear, but they may well require the further development of insulating devices devised to keep the flux of international problems from unstabilizing us, and to keep us from contributing most serious elements of instability to the international situation.

III *Compensating Mechanisms.* The development of automatic or quasi-automatic social mechanisms which absorb the shocks and make the compensating adjustments necessary to protect the fundamental stability of society against the new phenomenon of rapid change, introduced into the social environment by science and technology. The mechanisms should operate regardless of causes simply because the condition requiring adjustments exists. They should never wait on the understanding of causes, though of course efforts to understand causes should continue and will contribute to the perfection of such mechanisms of adjustment.

Any suggestion adopted must hold out hope of dealing successfully with changes of the types happening about us, and particularly with the results of science and management, or it is likely to hinder us in dealing with such changing conditions. The plan or mechanism suggested should itself be readily adapted to new conditions. The Bank of England was for many years an outstanding example of such a successful elastic mechanism. Our Federal Reserve Act fails to be such an example because of inelasticity in its provisions which make it unable to deal with our present problems.

All concrete programs not essentially of a temporary nature or dealing with fixed conditions should, so far as possible, be methods of dealing with changing conditions rather than specific answers to current facts. Remedies devised as present answers to changing situations may be obsolete before they can be put into effect, for the problem is rarely how to deal with static conditions.

EXAMPLES OF COMPENSATORY ADJUSTMENTS NEEDED

A few specific examples which come under this heading will serve to illustrate the approach here outlined. I shall discuss them primarily from a business point of view. Business suffers today from the loss of customers. These customers fall into two groups, foreign and domestic. I shall not now refer to the elements entering into foreign trade. It is enough for present purposes to state my judgment that we must depend for rebuilding our business structure on customers at home.

Three great subdivisions of this home group of lost customers appear on the most general analysis:

A—The unemployed
B—The psychological group. This group is again divided into the timid, who fear the loss of their jobs, and the wise, who are waiting for lower prices
C—The farmer.

Moreover while the causes of our present and of past depressions are obscure and vary with each episode of bad business, these three great groups recur in various former depressions, the first two in all recent cases.

Is it possible to set up or perfect compensating mechanisms which shall at least reduce these shocks brought

about by the multifarious forces which result in depressions? I believe so.

A—*Unemployment*. Certainly the causes of unemployment are obscure, and just as certainly we cannot maintain the stability in society which is essential not only to the revival of business but to the continuance of private capitalism unless we work out methods of preventing the recurrence of such wholesale unemployment as we now have. Business cannot be good while many millions of potential customers are unable to buy. Yet the only feasible way to make them buyers is to put them to work. The only real remedy for unemployment is work.

CONTINUITY OF EMPLOYMENT NECESSARY

Substantial continuity of employment should be given under changing conditions of progress, that is, in face of the fact that technological and management progress makes it possible constantly to accomplish more results with the same labor or the same results with less labor. It should also be given at all stages of the business cycle. Do what we may, this cycle will remain with us, and the surest way to minimize its fluctuations is to give basic security. These problems were worked out under our old agricultural economies with a large degree of success. They should now be solved by trial and error in our industrialized civilization. They can only be solved by elastic compensating mechanisms.

No general plan will be sound which fails to make at least substantial progress in these directions. At the present time, security of employment is our great obsession, and there is much danger of adopting plans which aim at such security while ignoring the other criteria of the problem. Any dole system so organized that it may become the basis for systematic political exploitation involves this danger. It will require the greatest public wisdom to care for the present unemployed without establishing a permanent system of doles. Unemployment insurance under government auspices or as a general remedy for unemployment is subject to the same risks. It is exceedingly dangerous and, in my judgment, thoroughly unsound. Having no actuarial basis, it will inevitably become a dole.

Any general plan should give men security through continuity of employment. Quick-acting and elastic methods of accomplishing this must be worked out. Certainly down to that minimum of unemployment which may turn out to be inevitable to furnish the fluid labor necessary for new enterprises, we should find ways of keeping men at work. It may be that for such a limited group as I have just mentioned unemployment insurance is necessary and workable. I doubt both the necessity and the workability. The remedy for unemployment is work, and as the result of prolonged study I believe the problem is soluble on this level. The fundamental risks must be removed for the great mass of people. Of course, they will prosper more when business is good and less when it is bad, but in the present state of our knowledge and of our manufacturing equipment the range of variation in prosperity can be above the basic minimum of security, and ought to be.

HIGH REAL WAGES AND CONTINUOUS EMPLOYMENT NECESSARY FOR GOOD BUSINESS

We need not worry about the general level of security once it is attained. The achievements of our leaders must rapidly spread through the masses and raise the standard of living, for it is now plain that the leaders of an industrial civilization can in no other way secure the customers upon whom their own opportunities depend. The stability level will surely go up as we secure greater control over nature and make progress in our knowledge of management. Henceforth high real wages and continuous work are a condition precedent to good business.

METHOD OF HANDLING UNEMPLOYMENT

The first step in any long-time handling of the subject should be the creation of adequate employment agencies, labor exchanges, and really accurate indices of unemployment, both nationally and regionally. The hours of labor of each individual worker should be controlled with reference to such indices at points which will assure work for all fit workers. I particularly do not mean that the hours of work offered by given factories should be controlled. Let each operate as many hours as it can or will. The limiting factor should be man power. It is obvious that under such a plan the hours worked would vary with the times, and they should be adjusted to the times as nearly automatically as possible. It is also obvious that no such plan would assure the building up of industry. Its principal effect would be to obviate the necessity of doles and charity with their consequent disturbance to the social structure.

Such a device should be supplemented by other plans or mechanisms which introduce new purchasing power into the situation when business slows down. Now we wait for bumper crops here and famines abroad, or for great new industries to evolve, or for wars or for some other adventitious fact which introduces the new purchasing power needed as a starter for industry. I believe that a central thinking agency can devise methods of introducing such purchasing power by thought-out plans, and that the indices of unemployment interpreted in connection with the hours of labor current at any moment can be used to determine whether such new purchasing power is needed or not. Good business would be dependent on solving this problem, and with the attention thus focused on it, I think there is real reason to believe we should find the answer. Government programs for public works can be one very important method of introducing new purchasing power in periods of depression.

B—*The Psychological Group of Lost Customers*. Both the timid and the wise subdivisions of this group can in my opinion be most rapidly and surely affected through the price structure and the credit mechanisms of the country. Men will not buy normally when they fear for their jobs, or when they believe they can buy cheaper a month later.

PRICES AND BUYERS

At the present time we are in the midst of the most violent price deflation the world has ever seen. The

catastrophic results of this situation can hardly be overestimated. We need an expansion of credit which shall start prices up in both commodity and security markets. The present price levels are unstabilizing not only labor and business but our whole middle class, on which so much of the future depends. Debts do not deflate with prices, and our society is run on credit. Much of the political disturbance in the world can be traced to this deflation.

Government debts, bank debts, insurance debts, all mortgages, and private debts of every description have had from fifty to one hundred per cent added to their burdens. England's going off the Gold Standard is more directly in my opinion the result of this deflation than of all other forces put together.

RESPONSIBILITY FOR PRESENT DEPRESSION LARGELY ON FEDERAL RESERVE SYSTEM

The responsibility of our central banking system for this situation is impossible to determine with quantitative accuracy. In my judgment it is, nevertheless, difficult to overestimate this responsibility. Partly from policies adopted but mainly because of inelasticity in the Federal Reserve Act itself, our central banking system has been unable to respond to this emergency. The types of paper eligible for rediscount no longer exist in the quantity and quality necessary to form the basis for the required credit. Over forty per cent of the banks in the four eastern reserve districts had less than ten per cent of their total assets subject to rediscount. They were unprotected by our central banking system. We have had cheap money but no credit. Our individual banks have been forced into an attitude of ultraconservatism. Without fault of their own we have had a perfect pestilence of liquidity. This has resulted in forced liquidation in the security markets, and in liquidation or stoppage of buying in the commodity markets. The vicious circle of deflation has continued under this pressure for more than two years. The credit and price structure was certainly not solely responsible for the start of these conditions. It is just as clearly one of the chief contributing agencies in their continuance. It is not without significance that all through this most drastic price deflation the modern world has ever experienced, we have kept idle or substantially idle and almost wholly separate from its normal relationship to our own and the world's credit structure something over twenty per cent of the world's total monetary gold supply. One of the first types of elastic mechanisms which needs to be evolved is some method by which our central banking system can level rather than accentuate these wild fluctuations in price levels. We need immediately some method of reversing present price trends. Security and stability in many directions are dependent on the solution of this problem.

INSURANCE NOT ANSWER TO UNEMPLOYMENT

As I suggested under an earlier heading, security for the mass of our people will ultimately involve old-age pensions and accident, health, and disability insurance on a broad scale for all needing such protection. All these problems have an actuarial basis and are proper fields for the application of insurance principles. The problems lend themselves to static solutions. By minimizing the risks of the future such measures will expand the sound present buying power of our people. Nevertheless, insurance itself assumes stability in other parts of the economic structure.

All insurance plans dealing with problems of this magnitude must assume fairly constant price levels. If this is impossible, the security given by any insurance plan may through changes in price levels become wholly inadequate to give the requisite relief to the recipient, or so unexpectedly generous that it becomes dangerously burdensome to the community. There is no more important problem than the restoration of price levels to their 1925 level.

THE FARM PROBLEM

C—*The Farm Problem* is not simple, but the time has come when we must recognize it as among the greatest of business problems, deserving the best attention of our best minds. I shall make no attempt to outline solutions of this problem, but I believe the solution, when found, will be in part of this elastic nature.

Time will not permit further illustrations of the type of situation which in my judgment will require attention under this heading of elastic mechanisms automatically acting to absorb the shock of change.

It is important, however, to note that great care should be exercised lest the mechanisms set up turn out to be in themselves inelastic as is the case with much of our present legislation.

DANGERS OF FEDERAL BUREAUCRACIES AND QUASI-JUDICIAL COMMISSIONS

Any plan that in its initial stages or probable development builds up a great Federal bureaucracy to control business, or powerful quasi-judicial bodies making executive decisions for business, fails to meet this test of adaptability. All the experience of the world shows that bureaucracies oppose change; they inevitably resist change in all situations over which they have control, for they themselves tend to avoid all kinds of risk except the greatest of all, that of relying wholly on precedent. Bureaucratic control over American industry, no matter how set up, either by government or by a private board authorized by law, would certainly destroy a large part of individual opportunity and tend to stratify our society into unprogressive castes. Quasi-judicial bodies in their very nature tend also to rely too much on precedent to meet the conditions of a changing world, and the time required to reach conclusions by judicial processes prevents the quick action which is often the essential element in dealing with changing conditions. Of course, conditions will exist where such treatment of problems is necessary. The Interstate Commerce Commission is a case in point, but we all realize the price in delays and in the stultification of initiative which we have paid for the constructive achievements of this commission.

Ours is a different problem from Russia's. For a time she can hope to make rapid progress through centralized bureaucratic control. She is applying in new surroundings, where they are greatly needed, discoveries, inventions, and methods that private initiative and property in other parts of the world have well worked out, and she has also the enormous task of equipping a great nation with factories. Of course she has no unemployment problem. With us, however, our progress at every step will be a venture into the changing unknown, and if we substitute a great bureaucracy or a quasi-judicial body for private initiative through plans of control, we shall not only slow down progress but at the same time lay the foundations for an easy transition to sovietism.

CENTRAL THINKING IS REQUIRED; CENTRAL CONTROL WOULD BE BAD

D—*A Central Thinking Agency*. The development of planning intelligence in our social organism is necessary, not controlling decisions but indeed constantly engaged in narrowing the range within which current social action must be based on immediate, reasoned decisions. The major task is to anticipate the slow trial and error of organic evolution. Any central planning agency should develop mechanisms to accomplish the long-time adaptations, insulating and compensating adjustments which I have just described. In this way only can the intelligent control of human social problems be achieved. The effort to control all or all significant current decisions by successive intelligent processes originating in a central mind or planning board will be as futile and as dangerous to the survival of our social organism and to progress as would be the intellectual control of our own functions in breathing.

Here the biological analogy is less apt than elsewhere. We have no brain for our social organism. The question to be solved by experiment is whether a group of men thinking only for society can be of service in influencing constructively our present governmental and private agencies. It would be dangerous to give power to such an experimental body.

So far as may be consistent with the needs of our people, any plan should maintain the maximum of individual opportunity. Most of the thinking in our social organism must be done by individuals actively engaged in their own affairs who make up the organism, and progress is dependent primarily on individual initiative and opportunity. But organized central thinking is essential if we are to obtain stability.

Such continuous central thinking, adequately supported by funds for research, will be required if we are by thought to anticipate the progress of evolutionary forces and by conscious effort devise types of adjustment to our social environment which have been the uniform result of successful organic evolution. The fact that this has been attempted in Russia under objectionable conditions is immaterial. We need a central brain for our nation, constantly studying its adjustments to both external and internal environment, to both foreign and domestic affairs.

CENTRAL THINKING CANNOT PREVENT INDIVIDUAL RISKS

Such a central agency should not attempt to abolish individual risks. Any one who chooses to seek personal opportunity through his individual initiative must take risks. His willingness and opportunity to do this are an important element in progress under private capitalism. Scientific progress often becomes social progress through the medium of individual opportunity and individual risk. In so far as the activities of the individual are not anti-social, he should be allowed to take such risks. In general, government ought not to stop his so doing or to protect him from the consequences of his own activities at any point above the basic level of security that should be offered to all. Steps in the direction of controlling his decisions and substituting for them the direct orders of a bureaucracy, whether of government or run by business, or the decisions of quasi-judicial commissions, should be viewed with great suspicion for they threaten economic progress. Plans that contemplate large control of individuals and of corporations engaged in miscellaneous industry would, I believe, inevitably lessen individual opportunity. Federal licensing plans almost surely will involve at the outset or in their later developments this type of control. To such extent as this is true, such plans are unsound.

AT TIMES LARGE INTERFERENCE WITH PRIVATE INITIATIVE THE ESSENTIAL FRAMEWORK FOR PROGRESS

Nevertheless, situations have arisen and many more will arise in which the public interest is so great that interference with individual freedom of action is necessary. Such situations should be faced at once for they may be the essential framework of security within which alone individual opportunity can continue. Our farmers find their export market for many crops gone and their prices controlled on the international market at points below the general cost of production. Until the necessary readjustments are completed, the farmers' case may be one that should be protected by this essential framework. Our very police force hinders private initiative, yet without it progress would be impossible. Certainly, proportion and fairness in railroad rates and car distribution were so important to all economic groups that the handicaps inherent in commission control were justifiably accepted as the price to be paid for general progress. Legal control over monopolies, whether public-service or otherwise, will always be justified, though the present Sherman and Clayton Acts go too far in the industrial field, and as a result bring greater evils than those they cure.

Control over private initiative is objectionable wherever it is not necessary for the attainment of larger objectives. If carried too far, it will bring revolutionary changes verging on sovietism. But control must be clearly distinguished from information. Progress depends largely upon the willingness and ability of the individual to take risks, and in general he should be left free to take them. Progress does not depend upon taking risks ignorantly, and the necessity of acting ignorantly is a terrific brake on progress. Few indi-

viduals or companies, unaided, can secure the information which should properly be available, notwithstanding the great inherent difficulties which stand in the way of securing facts. Business is too often the art of reaching correct conclusions from inadequate information. Any plan, to succeed, should provide through an economic council, or some other body, means by which the individual may secure not only facts but very competent interpretation of facts on which he may make more intelligent major decisions than are possible at the present.

E—*Planning for a Democracy* with its specialized problems. One further category must be added. These plans must be so worked out that they do not impose undue strains on our democracy, just as biological adaptations have been worked out through long eras of time without disturbing essentially the main characteristics of the human body.

DANGER OF OVERCENTRALIZATION IN WASHINGTON

All our experience teaches the growing dangers of centralization of authority in Washington. The United States is an exceedingly complex aggregate of diverse elements. Great government bureaucracies at Washington are ill adapted to an understanding treatment of sectional questions. Varying local problems do not lend themselves well to uniform treatment; our experience with national prohibition and so far our experiments in agricultural relief illustrate this danger. Our whole history indicates more and more that, once started, centralization tends to increase. In the nature of things, bureaucracies resist change, but not the extension of their function.

DANGERS TO GOVERNMENT FROM UNEMPLOYMENT INSURANCE AND DOLES

Federal and state unemployment insurance and doles fail to meet this test. The history of England and Germany clearly shows how easily unemployment insurance can turn into doles and how dangerous these are to the self-respect of workers, to the independence of government, and to the whole structure of society. No actuarial basis is possible. Skilful drafting of bills will not protect against these dangers. Unemployment insurance is not insurance. But we must not deceive ourselves. Under the employment conditions in England and Germany and in the absence of measures which would keep men at work supplying things they wanted, doles were inevitable. The alternative was revolution, and we shall avoid a similar situation only if we are able to solve our similar problems by saner methods that offer continuous employment in making the things our people want. Any plan, to offer hope of success, must include a solution of the unemployment problem that meets the conditions of a changing world, and yet avoids the creation of a great group of men who, having lost their self-respect, organize successive raids on the government to support them in idleness.

No remedy, plan, or system of planning, partial or general in its application, appears philosophically sound if on the whole it goes seriously and unnecessarily counter to these tests.

SUMMARY

They may be summarized briefly:

1 Does the plan contribute a durable improvement in our adaptation to long-time conditions in our social environment?

2 Does it appear to offer a wise addition to or modification of those insulating or defense mechanisms which our society has set up to minimize the dangers of external changes in our environment?

3 Is the suggestion one which offers an elastic method of absorbing or compensating shocks to our social organism brought about by the rapid changes which science and technology are causing in our external and internal environment, that is, in both foreign and domestic affairs?

Any plan which makes sound progress along the lines so indicated will contribute to our fundamental stability. But such plans will evolve very slowly unless we consciously seek them. Therefore we ask:

4 Does the plan, if it purports to be a general plan, set up an appropriate central thinking agency?

Any such agency should not direct its attention primarily at the continuous understanding of an impossibly complex flux of circumstances. It should study the impact of changes in the environment on the social organism, isolate those consequences of such impact that seriously disturb society, and devise mechanisms which shall as quickly and as nearly automatically as possible set up compensatory forces which prevent these changes in environment from unstabilizing society. Such a body should be given no control or inquisitorial powers.

5 Does the suggested plan impose unnecessary hazards on a democracy?

Plans or remedies that pass these tests must still take into account many other factors, such as simplicity, practicability, and probable efficiency, but the tests should not be overlooked in appraising plans directed at the solution of specific problems. Failure to take these factors into account will inevitably create unexpected results often more serious than the conditions such plans are devised to meet.

GOVERNMENT AND BUSINESS MUST COOPERATE TO SOLVE PROBLEMS

From such an analysis it will be clear that the central thinking or planning necessary to securing stability without destroying progress must be in part governmental and in part private. Any central bank is a case in point. The present inadequacies of government handling of situations and our distrust of it proceed largely from failure to recognize the elements of change and the time elements which are involved. The effort of our legislative bodies is constantly to find solutions of specific problems which will last, and to define them in fixed terms controlling conduct. This is in great groups of cases philosophically unsound. So far as possible these

mechanisms should function without delay. We must trust the future to make its own decisions, but we owe to the future mechanisms which will make decisions possible by maintaining stability while the inevitably slow processes which create public opinion and translate it into action are taking their course. Such stability cannot be maintained through written constitutions. It involves lessening or counteracting the shocks to the social organism by quick-acting mechanisms of adjustment. It is essential that these mechanisms shall neither destroy individual initiative nor place undue strains on our democracy.

The Government as well as business must cooperate on major parts of any such program. Long-time adjustments to permanent changes will require Government action. Insulating and defense mechanisms generally will be dependent on such action. Compensating mechanisms will ordinarily have governmental aspects—aspects requiring legislation to make them possible. We must overcome our feeling that these problems are to be solved wholly by business. They never can be. Many problems of security which must be solved for the individual are broad social questions not limited to industry and indeed not appropriate for industry to handle. Old age, sickness, and disability are not industrial problems. Employment will not be stabilized without government regulation as well as business acumen.

AN ECONOMIC GENERAL STAFF NECESSARY

In my judgment we should set up a general thinking body, an Economic General Staff, with no control or espionage power, containing men chosen by representatives of the Government, of industry, and of labor. One most important job of this Economic General Staff should be to study the principal shocks to which society is subject and to recommend elastic institutions or programs which will meet these shocks as nearly automatically and with as little delay as possible whenever they occur from any series of causes. Such a body would be futile or dangerous if given control. Society would either lose its vitality or more probably develop automatic and peculiarly dangerous extra-legal defense mechanisms to bootleg discretion back to industry. Espionage powers given to such a body would be unfortunate, for they would through the development of fear prevent the growth of influence.

This Economic General Staff should include a business research and interpretative division constantly studying general business problems and interpreting them. The function of such a division should be to give intelligent bases for business decisions.

BUSINESS CONGRESS IN CLOSE TOUCH WITH INDUSTRY NEEDED

Just as concrete government action would in general result from conclusions of the Economic General Staff only when Federal or State governments were convinced of the desirability of its recommendations, so the business recommendations of such a General Staff should have no effect except as it functioned through and convinced a representative Business Congress chosen by and responsible to the great industries and trade associations of the country. Such a Business Congress should be set up. On the one hand, I do not believe trade associations or special industries can handle our problems. On the other hand, I do not believe that any thinking agency can get results unless it is closely related to our industries through some representative body carefully chosen by the industries.

Specific criticism of the many plans and planning mechanisms which have been suggested is not possible within the limits of this paper. In general, planning mechanisms which involve or threaten central discretionary control of business by government or private agencies seem to me unsound philosophically. We need much more understanding of the foundations of our problem before we extend the control given to any body, however constituted, beyond the point it attains through the weight accorded to its reasoned conclusions.

No planning machinery can have the necessary effectiveness in securing stability and maintaining individual initiative and opportunity which is not related on the one hand to government and on the other hand to business. Business in its fear of government should not attempt to handle problems which are social, not business, problems. The end of that road will be failure and increased government control.

CAUSES OF TROUBLE LESS IMPORTANT THAN REMEDIES FOR SOCIAL DIFFICULTIES THEY BRING ABOUT

Above all no plan or planning mechanism can accomplish the necessary result if it ignores the philosophic foundation of the whole situation. We can never get adequate understanding of the current flux of events. "Circumstance is more swiftly changing than a shadow." We must deal with the consequences of forces too numerous for logical control and too fleeting for understanding. We must pick out the critical points where this changing environment tends to unstabilize our society, and discover modes of dealing with the few specific situations so defined.

The search for remedies is more important than the search for causes, though as in medical science a knowledge of causes will often aid in discovering remedies. Even where we have a theoretical understanding of the causes of similar situations in the past, that understanding in itself may prevent action, for always the momentary forces at work are obscure and the weighting of the elements is so complex that those who should act waste their time in futile discussion. Happily the results flowing from these complex causes, in so far as they critically unstabilize society, appear to do so in a few important ways. We must search out these ways and devise mechanisms adequate to counteract their effects. In so doing lies our opportunity of substituting organized intelligence for blind chance in our economic world.

We must not forget that nature is impatient of failure. The past is full of the wreckage of species which failed to adapt themselves to their changing environment.

THE ENGINEER MILITANT

Presidential Address at A.S.M.E. Annual Meeting

By ROY V. WRIGHT[1]

THE engineer has been subjected to harsh and severe criticism in these recent years. While much of this may not have been deserved, it promises to be helpful to the profession—strange as it may seem—if for no other reason than that it is forcing the engineer more thoroughly and critically to examine his part in and contribution to our economic program and progress. Moreover it is encouraging him also to develop a larger and stronger professional consciousness. Again, it is a clear indication that certain elements, at least, are looking to him for leadership in helping to solve some of our more pressing economic problems.

These are trying days, and in some ways they promise to mark a distinct turning point in the activities of our Society, and in the emphasis on its major objectives. We seem to be at the parting of the ways. With statesmanlike vision and constructive effort we may yet lift the engineering profession to the heights which it should occupy, in the light of its past achievements and of the leadership which it can help to give this present civilization. Stuart Chase has been a harsh critic of the engineer, and yet in his "The Nemesis of American Business" he makes this statement: "Plato once called for philosopher kings. Today the greatest need in all this bewildered world is for philosopher engineers."

WE ought to give more serious consideration to the building up of a stronger professional consciousness, which will weld the engineers more closely together and inspire and encourage them to greater and more constructive unified efforts in the interests of humanity. Of all men the engineer should take a larger and intelligent interest in helping to control all of the forces which have been set up as the result of our more complicated existence in this era of mass production. The very success of our nation depends upon the intelligence of its citizens and the extent to which they use this intelligence in working out problems of government—and these problems are steadily and rapidly becoming more serious.

We need militant engineers—aggressive and constructive—who will enthusiastically devote their energies to building up the engineering profession, raising it to higher levels, and will vigorously take the offensive in helping to find a solution of some of the great economic problems which we are now facing.

ROY V. WRIGHT.

WHAT ABOUT THE FUTURE?

Unfortunately, up to this time the engineer and those with whom he has been associated have been too prone to consider only the immediate results of their work, and have failed to vision the great forces which have been in process of development in our economic, social, and political life as a result of the complications brought about by this machine age, for which the engineer is largely responsible.

Was it a recognition of the engineer's responsibility in these respects that the artist attempted to portray so graphically on one side of the medal commemorating the Fiftieth Anniversary of our Society? Obviously the engineer pictured is looking over and beyond the tools and instruments in the foreground and is visualizing a world raised to higher levels and standards. Can the engineer render a larger or more important service than to insure the total results of his work, direct and indirect, being entirely in the interests of humanity? Those are indeed challenging words on the medal: "What Is Not Yet, May Be."

These problems and others have been brought home to me most forcefully as I have journeyed about among you this past year and have discussed with you some of the larger problems and challenges which are facing us. Quite naturally, therefore, there are a number of important tendencies concerning which I should like to talk with you this evening, if there were more time. I shall attempt rather to comment briefly upon only a few of the high spots.

CIVIC RESPONSIBILITIES

We ought to give more serious consideration to the building up of a stronger professional consciousness, which will weld the engineers more closely together and inspire and encourage them to greater and more constructive unified efforts in the interests of humanity. Of all men the engineer should take a large and intelligent interest in helping to control all of the forces which have been set up as the result of our more complicated existence in this era of mass production. The very success of our nation depends upon the intelligence of its citizens and the extent to which they use this intelligence in working out problems of government—and these problems are steadily and rapidly becoming more serious.

Is it not strange, under these conditions, that students are being graduated from our colleges and universities, many of which are supported largely by public funds, without having any clear understanding of the elements of citizenship, or how they can best serve their communities and country? Engineers must take these re-

[1] Presidential Address, at the Annual Meeting, New York, November 30 to December 4, 1931, of The American Society of Mechanical Engineers.

sponsibilities more seriously—as individual citizens or as groups in assisting their localities in city and county planning, or collectively by taking a larger part in public affairs of the state and nation.

We can, for instance, well take pride in and ought to support generously and with enthusiasm the work of the American Engineering Council, which represents the engineer in public affairs and has done so much also to bring the engineering attitude to bear in important economic studies. One of our members, L. P. Alford, was recently awarded the Gantt Medal, partly, at least, because of the outstanding part that he has taken in the making of these engineering economic studies in the public interest. Our President-Elect, Conrad N. Lauer, was mindful of the engineers' responsibility for public service when he founded the Hoover Medal, the purpose of which, in the words of President Hoover, "is to mark the public service of men who have gone outside their strictly professional work to interest themselves in civic and humanitarian affairs."

ELEVATING PROFESSIONAL STATUS

Study and discussion of the report on the status of the mechanical engineer, which was so ably prepared under the direction of a committee headed by President-Elect Lauer, indicates that there are possibilities of greatly improving the status of the engineer, which almost automatically should bring home to him more forcefully his responsibilities to the community at large.

If this is to be done thoroughly, however, it means a rebuilding of our structure from the very foundation. One of the evidences of an intelligent appreciation of this is the fact that more and more thought is being given to the better selection of young men who enter our engineering schools. In some instances members of the faculties of engineering colleges are getting in touch with the high-school authorities and are trying to locate, particularly through the science teachers, boys who seem to be particularly well adapted for engineering and who should be encouraged to enter that profession. Stevens Institute of Technology, under the direction of its president, Dr. Harvey N. Davis, also one of our vice-presidents, this last summer gathered a group of junior-high-school students at its camp in northern New Jersey, with a view to giving them a thorough understanding of what engineering is, and of the requirements for success in its various phases; at the same time an attempt was made scientifically to study and analyze each boy, with a view to encouraging those who were specially fitted for engineering to enter that profession.

OUR STUDENT BRANCHES

Our Society has done good work with its Student Branches, but has not approached the problem with the same type of statesmanship as in the supervision of the Local Sections and the Professional Divisions. The committee in charge of this work is to be congratulated upon the forward step that it is now taking. The experiment with the new set-up is at present confined to 15 Student Branches in the Southeast, but there are good reasons even now to believe that it will be a success and that, when extended to all of our Student Branches, it will more closely integrate the activities of our Society with the engineering colleges. Rightly directed, this means that it can be of very great assistance to the engineering faculties and students in a practical way, and will help greatly to develop a proper professional consciousness among the students; it should also, almost automatically, bring these young men into the membership of the Society. We have to too great an extent neglected these students. It will mean much to them if in the course of their training they can touch elbows with the experienced and practical engineer. Indeed, their future success depends largely upon the extent to which we reach out a helping hand to them.

THE JUNIOR MEMBERS

We have been so intent and so serious in promoting our technical programs that we have lost sight of some of the large opportunities for strengthening the Society and insuring its future stability. What, for instance, have we done in a constructive way to encourage and help the young graduate engineer? He needs our friendship as well as our helpful interest and encouragement. If he has come to our meetings, too frequently we have paid little or no attention to him, or have given him the cold shoulder. This neglect has not been intentional. We have simply failed to see the young man and to realize how much he needs coaching and encouragement; and too often we have lost him from our membership, possibly never to return. It is a question as to whether any other activity needs our attention so much at this time as the development of constructive and aggressive plans to assimilate the Juniors into our activities. They need us, but we need them with their youth, enthusiasm, aggressiveness, and courage. And then, too, this is one of the very foundation stones for building a larger and stronger professional consciousness.

TECHNICAL MEETINGS COLD AND INEFFICIENT

Engineers are not cold-blooded. Indeed, as we come to know each other as individuals, we find that we are intensely human. For some reason, however, our meetings have lacked much of that spirit of warmth and good-fellowship which is so vital if we are to come to understand each other better and to be mutually helpful to as great an extent as possible. Judging from numerous comments that I have received, many members fail to attend meetings because of the lack of this spirit. Some of our Local Sections are deliberately organizing to introduce a spirit of good-fellowship into their meetings.

We have been careless also in attending to the appointments and details which go to make the technical handling of the meetings a success. It is not enough to find some one who will prepare a paper or make an address, send out a formal notice to that effect, and then perfunctorily carry out the program. Staging a successful technical meeting is an art. Incidentally, even an ex-

perienced speaker has difficulty in overcoming some of the handicaps that are thoughtlessly placed in his way. Even a machine must be treated with reasonable consideration, but fine discrimination must be used with a human being if he is to give the best that is in him. Oh! how careless and thoughtless some of our members and groups can be—and never even realize it! Surely a profession that prides itself upon eliminating waste and increasing efficiency in industrial operations can master the technique of putting over successful technical programs.

We have not made the best of jobs in selling ourselves, either to the mechanical engineers who are not members of our Society or to the public. We can well take a lesson from the constructive piece of publicity work that has been done by the chemical engineers. Few things will do more to enhance our prestige or develop a larger professional consciousness than a carefully planned publicity campaign—and, personally, I believe this can well be done by the engineering societies jointly. It will cost money, but, wisely directed, it should far more than pay for itself.

ENGINEERS, NOT SPECIALISTS

Up to this point I have carefully refrained from mentioning the mechanical engineer as such. Not that I am not proud of the profession and of this great Society which so ably represents it, with its multitudinous and far-flung activities. Basically, however, we are engineers, having the same fundamental training and, in a large way, the same objectives as other branches of engineering. We are seeing recognition of this in the fact that engineering colleges more and more are thinking in terms of the engineer rather than of the specialist. We see it in the extent to which graduate engineers shift from one type of engineering to another. We see it in the tendency for specialized groups of engineers in a community to combine in federations or all-inclusive clubs, each type of engineering functioning as a group within the larger group. We see it again in the extent to which our national engineering societies more and more are engaging in joint activities—in technical meetings, in our Engineering Societies Library, in public service through the American Engineering Council, and now, let us hope, in a joint program looking toward the elevation of the status of the engineer.

Many years ago one of our most honored members, a past-president, Ambrose Swasey, made possible the formation of the Engineering Foundation. With clear vision and unfaltering step he has never lost faith in this joint activity for the promotion of engineering research. Within recent months he has generously added to his already liberal contribution to this project—a challenge to all of us to put forth greater effort in this worthy joint activity.

Rapid shifts which have taken place in our industrial and economic life in this era of mass production have brought home to us in no uncertain manner the fact that the engineer must be so trained that he can readily adapt himself to new and greatly changed conditions. Indications are that such changes may be even more numerous and radical in the days to come. Just as business and industry should protect the worker by cooperation to provide a continuous training throughout his service life, in order that he may keep up with the advancement of skill in his craft, so the engineer must have a broad basic training in order that he may readily adjust himself to new and unforeseen requirements. This again emphasizes the fact that we should train engineers—not specialists.

WANTED—MILITANT ENGINEERS!

Vice-President Ralph E. Flanders has recently published a book entitled, "Taming Our Machines." He is not a pessimist. Indeed, those of us who know him well have been impressed by his optimism and his enthusiastic, constructive attitude. He is a builder, not a wrecker. Listen to this challenge from the last chapter of his book:

> If our age of machines cannot assure, on the whole, a steady and considerable flow of sustenance and the opportunity for leisure for all who are able and willing to work, it has failed in the end which it was best adapted to serve. The whole social fabric built upon our machines will then slowly crumble and decay.
>
> The process of decay, however, will be hastened by direct attacks which are being organized at this moment. The political battles of the present and future are visibly concentrating about our economic failures. If we, who are the sponsors of the machines and of the industrial society built upon them, can successfully organize them to the ends of general human satisfaction, and if we can join to ourselves the other groups whose cooperation is essential, or if we can join ourselves to them in some effective way, then this civilization which we have built will endure. Otherwise it will perish. No mere defensive tactics will avail in this critical undertaking.

Stuart Chase calls for philosopher engineers, but we need something more than this. We need militant engineers—aggressive and constructive—who will enthusiastically devote their energies to building up the engineering profession, raising it to higher levels, and will vigorously take the offensive in helping to find a solution of some of the great economic problems which we are now facing.

AS A MATTER OF FACT, whether he realizes it or not, the engineer of today is in truth a practicing economist, and but very little of that much-abused term "scientist." Engineering differs from science in that it is concerned with the proper balance between cost, use, and other derivable benefits; whereas pure science is concerned only with the derivation of effects and results, without particular regard to cost or practicable application. It may be said, then, that engineering is the creation of mediums of purchasable usefulness, in that the structures or methods it creates must stand the very acid test of economic use and justifiable cost—or not be brought into existence. These creations, from the standpoint of the engineer, may be any physical evidence of the progress of mankind. Primarily, however, they must be, in common parlance, "worth the money"—or not be built.—F. H. McDonald in *Civil Engineering*, December, 1931, p. 1362.

THE ECONOMIC ASPECTS OF STABILIZATION

By VIRGIL JORDAN[1]

I QUOTE from a recent statement by a distinguished colleague, Prof. T. E. Gregory:

> The problem confronting the world today is one of *will*, and not of *knowledge*. It is possible to lay down the conditions upon which, and upon which alone, recovery is possible, but it does not lie within the competence of the economist to guarantee that there is enough will power, imagination, and determination available to carry out the details of the solution. . . . The economist's task is done when he has diagnosed the disease and indicated the remedies; the rest must be left to men of action.

To the economist the problem of promoting recovery from this depression is much less difficult than the task of fostering the future stability of business; it is equally within his power to indicate the conditions on which stabilization will be possible; but he can give no assurance that the forces of political leadership and public psychology will be forthcoming to support his prescription; and in forecasting the outcome he can rely only on his understanding of those underlying factors of blind human need and desire that ultimately determine the destiny of economic and social evolution.

To the economist, the concept of stabilization, as applied to an advanced industrial society such as that which has developed in these United States, has a simple and clear significance. It means merely the maintenance of a continuously increasing consumption by the people of this country of the goods and services which they are able to produce themselves or buy from abroad by their labor. It has no other necessary or ultimate meaning. It does not imply the maintenance of any particular level or condition of prices, wages, business profits, or capital values. In fact it is precisely because individuals and groups believe it does, that instability is so serious and constant a characteristic of our economic system.

VIRGIL JORDAN

The essential conditions of stabilization in this country can also be set down simply and clearly.

In the first place, business stabilization in the United States is possible only on the basis either of comprehensive and continuous international cooperation or of carefully and completely controlled isolation. As I shall point out later, neither of these conditions is fulfilled in the existing situation, and the second is the only one that is ever likely to be realized.

In the second place, stabilization is possible within the capitalistic structure, which is permanently established in this country, only by virtue of a more continuous and consciously controlled conversion of individual and corporate savings and/or of bank credit into consumer purchasing power, with a corresponding dissipation of capital and writing down of capital values. This, as I shall explain later, is essentially the process by which alone capitalism survives in every advanced industrial country; but at present it proceeds in periodic spasms of confiscation through cycles of inflation and deflation in which purchasing power is blindly redistributed and the balance of production and consumption brutally rectified. The only reason for talking about stabilization at all is the assumption that there must be some less wasteful way of doing the same thing. The outcome itself is inescapable if the system is to survive.

Thirdly, even though these conditions may be met, they cannot assure stability unless the structural organization of industry and trade is such as to satisfy certain instinctive necessities of the individual, necessities which may be summed up in the concepts of security and freedom. These concepts cover much more than the simple sense of economic insecurity upon which Dean Donham has properly laid so much emphasis as a factor of business instability. They fall within the field of

---

[1] Economist of the McGraw-Hill Publishing Company, New York.

Presented at a session on stabilization held at the Annual Meeting, New York, November 30 to December 4, 1931, of The American Society of Mechanical Engineers, under the auspices of the Management Division with the cooperation of the American Management Association.

the psychologist and psychoanalyst, and have therefore unfortunately been ignored by the economist until recently. This depression has taught us, however, that they are of prime importance in the problem of stabilization, and that no economic system, no matter how perfectly balanced it may be in the mechanical or strictly economic sense, can be considered stable which does not meet the psychological requirements of stability. We have learned, in very concrete ways, for example, that continuous consumer demand is dependent not merely upon consumer purchasing power in the strictly accounting sense, but also upon conditions of consumer psychology which we so far understand little about, and are still satisfied to sum up in the vague term "confidence."

These factors seem to me too important an aspect of the problem of stabilization to be ignored any longer by either the economist or the business man and banker. They concern him vitally because, in the final analysis, they are intimately involved with certain aspects of the structure of the business and credit organization, particularly its concentration and centralization, which require careful consideration in connection with projects for national industrial or economic planning. It is my opinion that profound changes are taking place in the structure of American as well as world business, in response to unseen underlying physical forces arising from the application of electric energy, and that the hope for greater stability rests more on the outcome of these changes than on any conscious and deliberate stabilization effort. Recalling the somewhat despairing statement of Professor Gregory with which I began, I should be pessimistic indeed about the prospects for stabilization if it were not for my faith in the outcome of these unconscious forces which do not depend in any great degree upon deliberate human action.

Having stated in somewhat abstract form the essential conditions of stabilization as I see them, let me sketch the extent to which those conditions are likely to be realized under the various lines of action that have been proposed.

STABILIZATION POSSIBLE ON A NATIONAL BASIS

I said that stabilization within the United States is possible only on the basis either of comprehensive, continuous international cooperation or of carefully controlled isolation. The first is an abstract ideal that will never be realized, at least in the form in which it is conceived today, with some sort of international currency and some supernational commerce commission regulating the international flow of goods and services.

The fundamental forces point in the opposite direction. There is evident a definite trend toward intensified nationalism, which is the first expression of an underlying process of decentralization that marks the disintegration of capitalism in its present form. International trade and borrowing will be of diminishing importance relative to domestic trade and investment in every country, and many raw-material and skilled-labor monopolies upon which international trade has been built will be broken by synthetic chemistry, as indigo, nitrate, and silk have been, and by universal mechanization. Economic differentials dependent upon geographical interest will ultimately cease to be of importance, and the motives of international cooperation will lose their force. This is still a long way off; in the meantime the problem of stabilization can be profitably approached only from the national point of view. This does not preclude international intellectual contact, intercourse, and cooperation, the chief result of which, however, will be to promote more effective stabilization nationally, not to foster actual international economic cooperation.

Stabilization on a national basis is perfectly possible, but it requires centralized control over exports and imports and foreign investment. Putting it the other way around, national stabilization is impossible without such control, and with the existing freedom to oversell or overbuy, overlend or overborrow abroad. This is because national stability is now completely dependent upon certain credit and banking conditions which cannot be effectively controlled without prior control over external influences arising from international trade and finance.

Such control is now being exercised by every European country. It will not be applied to any large extent in the United States because of the banker and investment interests dominant in a creditor nation. Defaults and moratoria during this depression may wipe out a large part of our creditor position, check the increase of foreign investment, and permit better balancing of trade; but the probabilities are that we shall have at least one more inflationary boom in which (*a*) we shall give away a lot more goods to the world on credit, and (*b*) maintain a high tariff to prevent repayment. Banker interests will support the former; industrial and labor interests the latter.

We may look, therefore, for a long period of casuistic compromise between certain superficial forms of international cooperation largely dictated by financial and exporting interests, and a contradictory, unintelligent nationalism reflected in crude tariff policies dictated by domestic industries and labor organizations. This compromise will be further complicated henceforth by the problem of gold reserves and devaluation of currencies. These are being and will be used as weapons of political and economic nationalism for the purpose of establishing certain trade areas and groupings like Franco-Europe and the British Empire, and the prospects of any effective international currency or banking cooperation to correct these complications are remote. Few nations now can handle even their internal banking problems successfully.

The result is that for a long time domestic efforts at stabilization must be carried on in face of unstable and disturbing influences from abroad. The consoling thing is that these influences are likely to diminish naturally in the course of time. In the meantime it will be difficult to accomplish much, but something can be done to diminish their force.

THE REAL PROBLEM OF STABILIZATION

Before we can understand what this is, it is necessary to explore the idea of stabilization a little more deeply. The desirability of stabilization is a little too much taken for granted in discussion of it. I am a stabilizer, but I believe that the importance or meaning of stabilization cannot be fully understood until we get a clearer idea of the significance of instability—its function in our economic set-up. The real problem of stabilization is how to get the advantages of instability without its disadvantages.

Wide business fluctuations are obviously a symptom of defects in our economic institutions; but what is not so obvious is that they are a rough—too rough—way of remedying the consequences of those defects. The central defect of capitalism as we now know it is the lack of any systematic or efficient mechanism of income distribution—of dividing the product of industry between wages and profits. The reason why this is serious is that it prevents a balance between saving and spending, consumption and production, upon which stability depends.

Modern industry—and agriculture, too—based not on labor but on utilization of an unlimited fund of solar energy accumulated in coal, oil, and water power, is so productive as compared with human and animal energy dependent on food, that prices would disappear and profits, wages, and capital values could not be maintained without some sort of systematic deliberate or unconscious sporadic sabotage by employers, financial interests, and labor. But despite all this sabotage, productivity still increases at such a rate that prices, profits, and return on capital can be maintained only by an equally rapid increase of consumption and consumer purchasing power. A larger and larger part of the product must go to those who spend their income, immediately or in advance (by consumer credit), and the rest must reinvest their surplus income more and more promptly (and continually in excess of their savings, through bank credit) in order to retain it. And, further, this reinvestment must be continuously or periodically confiscated or transformed into consumer purchasing power without return in order to keep that consumption up to production. Capitalism in every highly developed industrial nation is essentially a system under which we are compelled continuously or periodically to eat our cake in order to have it.

Ideally, the conditions of the problem set by modern industrial productivity require for stability one of two things: first, a continuous expansion of credit media of exchange in keeping with the energy used in production, as measured by man-hours or kilowatt-hours, until labor and industrial capacity are fully employed—that is, up to the point where inflation begins; this means a stable price level, which indicates that consumption and production as a whole are in balance. The alternative is some systematic means of converting surplus purchasing power into consumption without increasing productive capacity—by a combination of appropriate taxation and public borrowing, using the proceeds for providing public services of non-competitive character.

Neither of these conditions is fulfilled under the controls that exist in the capitalistic system at present. Instead, what happens is this:

We have periodically—largely under influence of international forces—gold or credit inflows, a process of credit expansion which runs into inflation because of defective banking and investment systems. In the latest form, as seen in 1922–1929, we have an excess of previous savings, swollen by large profits, supporting and supplemented by a pyramid of capitalized bank credit, transformed into consumer purchasing power principally through expanded construction of productive capacity, partly through instalment sales of goods, and partly by overflow into consumption of speculative profits. The consequent rise in prices during the process and before the productive capacity comes into use, constitutes a concealed confiscation of capital as the real value of dollar return on capital falls and the burden of fixed debt diminishes.

It is becoming more difficult to determine definitely on which side—consumption or saving—the balance of loss occurs during inflation periods. On the one hand the modern investment machinery makes for accelerated speculative profit, which in part only can be actually reinvested and tends to overflow into luxury consumption, but is fully offset by speculative losses during subsequent deflation. Actual investment of savings or profits or credit capital shows up in increased productive capacity more promptly and thus tends to depress prices sooner or more continuously. This tends to increase consumer purchasing power more promptly, and is reflected in the complaint of "profitless prosperity." The extended application of instalment selling also tends to turn more of the expanded bank credit into consumer channels. But on the other hand the investment of savings in construction, under modern methods, involves proportionately less and less labor, so that the conversion of capital into consumer purchasing power in the form of wages becomes less and less effective. Also, with the spread of participation in security speculation among all classes, more and more purchasing power is withheld from consumption and is subject to subsequent loss during deflation. On the whole, however, I think the balance of loss tends increasingly to fall on the side of savings or investment, even during inflation.

At any rate, when the new productive capacity comes into use, production again runs ahead of purchasing power and the decline of prices and depression set in. The capital savings or credit that have gone into consumer purchasing power during the boom are then registered on the investors' books as losses—written off—by the depreciation of inventories, of security values, by defaults, moratoria, and business failures. There is an additional direct conversion of capital or savings into consumption as bank deposits are drawn upon for current needs. Foreign loans made during inflation periods, not offset by balancing imports of goods, are another phase of capital dissipation, since the proceeds are really paid out to domestic workers and losses borne

by investors during depression. All this constitutes, of course, a vast redistribution of purchasing power in which capital is dissipated or changes hands at reduced value, but in the meantime the difference has in large part passed into consumption during the boom. And only when the profit requirements or overhead are sufficiently reduced to be met out of the current level of purchasing power plus consumers' savings, does business recovery begin and the cycle start again.

During the depression, labor of course loses by unemployment and lowered wages as much as or more than it gained in the transformation of capital during the boom; but this is offset in part by lowered prices and in part by diversion of capital funds into consumer purchasing power through private channels of charity and public channels of borrowing and taxation for unemployment relief. So here, too, it is probable that the balance of gain is on the side of the consumer and of loss on the side of savings, so far as the money accounting goes.

This process does work out on the whole and after a fashion to the extent that it does result in a continuous dissipation of capital and confiscation of savings and profits, to the end that consumption in the long run is balanced with output. The cycle is essentially only a phase or aspect of the process of diffusion or distribution of purchasing power in capitalistic society. That process is continuous; booms and depressions are only extreme or special manifestations of it. Year in and year out, in all phases of the cycle, consumer expenditures run ahead of the national income by a practically constant percentage which represents the chronic dissipation or degradation of capital, that is, its reversion to consumer income. That is the only way competitive capitalism gets along at all.

But obviously, in this economic organization, this is a very disturbing and increasingly dangerous process, even though one cannot be sure of oneself in calling it wasteful. There is, of course, the obvious loss or waste of unrealized potential productive power during depression, which implies a slower rate of progress in terms of rising standards of life—but whether unrealized productive power can be called waste is a question. More immediately serious are certain consequences that threaten to disrupt the structure and organization of the system. These are essentially psychological. First, the cumulative sense of insecurity which this cyclical process of capitalistic confiscation sets up in both investors and workers has become a powerful force preventing the smooth operation of the financial mechanism on the one hand and the industrial on the other. Hoarding in all its forms, capital strikes, flight of capital all threaten a complete breakdown of the banking system; and the sense of insecurity in the worker profoundly affects consumer demand, regardless of purchasing power or prices, and so threatens the very existence of organized large-scale industry. Finally, of course, this sense of insecurity sublimates itself in social aggression, political disturbance, and international conflict.

So, no one can safely recommend this process as a permanent scheme for solving the essential economic problem involved. Competitive capitalism must be recognized as an essentially unstable system, bound to be transformed in one direction or another. The underlying problem is, in what direction?

I myself do not think that the direction of communism or any of the many forms of centralized socialization is the way out. These strike me as fundamentally as unstable systems as present-day capitalism, but for somewhat different reasons. Fundamental forces, purely physical in character, arising out of the consequences of the use of infinitely divisible and widely distributable energy, will determine the form of the stable system that will evolve, and that will be a greatly diffused, decentralized, highly localized, and nationalistic capitalism. Everything that runs counter to this tendency, whether communism or capitalism as we know it, will be unstable and will not survive.

THE TRANSITION PHASE OF STABILIZATION

Our immediate problem of stabilization in its national aspects is to deal with the transition phase, the period of perhaps twenty to fifty years that lies ahead. Let me say, parenthetically, that I see no permanent results for stabilization from this depression. It will be followed by at least one and possibly several booms in the grand style of the last, perhaps shorter and sharper, but not essentially different. Nothing in the situation as regards essentials of stability has been changed. We have merely accumulated the makings in this country of another inflation on a vast scale, and nobody will stop it. We may have some changes in our banking system, but these will only help intensify the instability, not control it. We may also have some attempt to pluck a few feathers of profits from the capitalistic goose to make some slight cushions for labor through unemployment-insurance reserves, but these will not be adequate to deal with the essential problem of balancing consumer purchasing power with production.

Undoubtedly the next cycle or two of boom and depression will be distinguished only by a more intensive drive toward social legislation in all its forms—that is, protective means for ameliorating or easing the strain of unbalanced production and absorption upon workers. But this will involve greater centralization, intensify the concentration of industry, and run counter to the fundamental physical and psychological conditions and economic requirements of stability. It will tend only to run to state capitalism, solidify further the centralized capitalistic structure already too rigid, and cause its catastrophic collapse and disintegration instead of the slow transformation that is desirable. It cannot make for stability—save in the sense of petrifaction.

In this period, too, we may have—as we have had during this depression—a great deal of lip service to the slogan of "planning." Some of this will be sincere and, in certain restricted aspects, successful effort in individual concerns; possibly there may be some vague gesture toward it on a national scale by setting up a sort of economic council of stuffed shirts supported by a

staff of slide-rule operators; but probably most of this will pass out of the picture in the next boom period.

At any rate the only possible or probable application of the planning concept will be in industry, through the trade organizations for the purpose of negative stabilization in the sense of production control and price fixing, with employee protective measures thrown in incidentally as a sop to labor and suspicious legislators. This "planning" a la cartel is an extreme symptom of capitalistic self-defense. It has for its essential purpose to check the process of competitive confiscation which is the only automatic safety valve by which the survival of the system is assured; and it further tends to sterilize the element of technological improvement implicit in that process. Moreover it inevitably implies an intensification of centralization, and so cannot prove to be of any permanent importance because the undercurrent is in the opposite direction.

But, quite apart from the fact that the fundamental forces that have set in are opposed to industrial centralization and concentration (nationally as well as internationally), and also apart from the fact that idea of deliberate production control or organized sabotage sanctioned by law is fundamentally fallacious, there is a more immediate and obvious weakness in the concept of planning as applied to industrial management. This lies in its naive assumption that industrial management or organization per se can have any effective influence on the business cycle, everything else remaining the same. As a matter of fact I see no evidence at all that this depression was due in any measure to defects in industrial management, except possibly for some slight follies in financial policies of corporations, for which they were not to blame in the first instance. Nor do I believe that there is anything of vital importance that industrial management itself can do to prevent catastrophes of this sort. Your cycle starts in forces that lie almost wholly outside the sphere of influence of industrial management, and no stabilization effort is worth discussing seriously which does not deal with them first.

These forces—those of inflation and deflation—center in the price level, and they originate in and can be controlled only through the financial system in the broadest sense, not through the industrial structure and its operating management. The utmost that industrial management does is to play into them and intensify them in a moderate degree. By the financial system I mean, first, the private banking organization, including the regular banking structure, the investment-banking system, the brokerage business, and the security exchanges; and second, the governmental fiscal machinery, including the tariff. All these together, and not any policies of industrial management, control the relation between saving, investment, and spending which determines the flow and distribution of purchasing power, the distribution of wealth, the balance between production and consumption, the price level, and the relation between creditor and debtor groups. Out of these relations the business cycle issues. The cycle is a financial phenomenon, not an industrial affair. The best proof of this is not that we did not have depressions before the modern credit system, but that we *did* have them before the industrial system.

Until this is recognized we shall make little real progress toward stability. The first and most important step toward stabilization is the social control of our financial machinery. And I believe that if this is done, almost nothing else is necessary. Given effective control of our banking system and fiscal policies, industrial management and organization may be left almost complete freedom—and the greater freedom the better. They will be able to do little damage, and the urge of individual initiative will induce advancement. In the end such initiative will serve as a constant check on concentration—which is the outcome of financial factors—and conform to the fundamental tendency to decentralization which is implicit in the physical factors underlying our economic evolution. This itself will make for greater stability.

The immediate approach to stabilization, therefore, lies along the lines of credit control and fiscal policy, not of industrial organization and planning. This is the more difficult approach because industrial planning, as at present conceived, really plays into the hands of vested interests—of creditor groups, organized labor, and governmental bureaucracy—while credit control and fiscal engineering involve violent conflicts with them. The essential significance of the Soviet experiment is not its effort at industrial planning, which has serious weaknesses, but its decisive attack on the credit problem. The greatest handicap of capitalism is its archaic and ingrown credit and monetary system; that of communism is inexperience in machine technology and industrial management These handicaps are both serious enough to make the two systems about equally matched; but machine operation and industrial management can be learned; improvement of the credit mechanism is essentially a problem of class struggle. Britain has begun to realize this, and it is the submerged issue in British politics today.

Socialization of finance in its essentials within the framework of the capitalistic system of free industrial enterprise appears almost impossible without profound political upheaval, because the forces opposed to it are so powerful; but I believe there is some promise of slow improvement, aided by the pressure of physical or technological influences now at work. This depression and the banking and fiscal situation it has given rise to afford an unparalleled opportunity for fairly rapid progress if those who understand the problem will only organize to take advantage of it.

STRENGTHENING OF FEDERAL RESERVE SYSTEM

It is useless at the outset to work for any outright nationalization of our central banking system. Even in England, where the banking structure is simple, this is recognized. Public opinion is not ready for it, nor are we technically prepared for governmental banking operation. Moreover powerful private banking and investment interests are opposed to any such experi-

ment, and will be able to frighten the public and, if necessary, sabotage any steps in that direction in very destructive ways. The fact is that the basis does not exist as yet for any direct governmental control over banking and investment. There really is no such thing as the Federal Reserve System, as a central banking organization. The idea is implicit in the Federal Reserve Act, which is the most important piece of economic legislation ever passed in this country, but its framers were frustrated in their attempt to carry out its full intention by the influence of special interests. We have only a system within a system, a group of powerful private metropolitan banks which control both the Reserve banks and the mass of smaller member-banks throughout the country. They are the real sources of reserve credit; they are closely tied up with the securities markets; they dominate the money market; they control the only important Reserve banks; and the mass of smaller member-banks throughout the country are utterly dependent upon them, in loose ways not controlled by law, for access to reserve credit resources. Through their security affiliates, their holding companies, their chain and branch banking systems, which they are insistent on spreading, they have established an effective but invisible centralization of credit control. This control is exercised almost solely in the interest of the security markets, domestic and foreign, and not in the interest of domestic business stability or the security of depositors. The ineffectiveness of the Federal Reserve System in this situation is sufficiently demonstrated, I think, by the fact that in such conditions as have arisen in this depression—a practical collapse of our credit machinery throughout the country—the nominal Reserve System is practically set aside, the inside, concealed reserve system is brought into the open as a National Credit Corporation; and, as will be seen when Congress assembles, it finally becomes necessary for the Government to set up separate and new reserve credit agencies by reviving the War Finance Corporation as an emergency national banking institution.

I feel, therefore, that the first step toward stabilization must be the strengthening of the Federal Reserve System so that it may meet the credit needs of industry and trade in the democratic way in which it was intended to serve them. This requires revision of the Reserve Act, first, so as to insure greater security for bank depositors and prevent the possibility of repetition of that collapse of confidence in our banks which has so seriously crippled the country during the latter stages of this depression; and second, so as to insure greater independence and more democratic access to reserve credit resources on the part of the individual member-banks throughout the country. These purposes require complete and compulsory inclusion of all commercial banks within the system; establishment of insurance reserves within the Reserve Banks to guarantee bank deposits; and the widening of the provisions and regulations regarding the classes of assets eligible for rediscount. All these things parallel the proposals of the Swope plan for establishing unemployment reserves to protect workers and for strengthening the trade associations, but seem to me of much greater importance for business stability.

In addition, certain specific changes are necessary to secure greater control over the money and securities markets in the social interest. The security affiliates of commercial banks should be separated by a Caesarian operation. It should be made definitely illegal for member-banks to engage in the selling of securities either directly or for trust accounts; possibly the trust functions of commercial banks should be more strictly controlled or likewise divorced. Their handling of corporation funds for loan in the call market without contingent liability should be controlled. Finally, it will be necessary to establish a separate system of reserve credit resources for rediscounting intermediate and long-term loans to industry, trade, and construction, similar to the intermediate credit and land banks for agriculture. The functions of the Federal Reserve System as it stands should not be complicated by taking on these additional essential tasks.

STABILIZATION THROUGH CREDIT CONTROL

These changes will make for greater business stability by providing a more elastic and controllable credit mechanism without resorting at one swoop to socialization of our banking system; but moderate as they are they will meet bitter opposition from private banking interests and will mean a long and bloody battle before they are achieved. There is more immediate promise of progress in the other half of the picture—that of fiscal policy. This is not only inseparably connected with credit control, but it is an important independent weapon for promoting stability. In fact, although I attach great importance to improvements in our banking system, I believe that more can be accomplished quickly toward stabilization by appropriate improvements in our fiscal system than in any other way.

The problem of balancing production and consumption with which the industrial planners are preoccupied is essentially one of increasing purchasing power for consumers' goods, rather than of curtailing output. This can be met indirectly by continuous controlled credit expansion, but this requires changes in our banking system and psychology which will be difficult to achieve, fundamentally because it involves a continuous, concealed confiscation of claims to income through inflation. Moreover, even though this difficulty be overcome or disregarded, it must remain doubtful whether we can successfully or accurately finance consumption by the indirect process of financing production, for which our banking mechanism is primarily designed. What we need primarily is a direct diversion of savings or credit capital from competitive production into consumption. We do not have to destroy profits by the wasteful process of competitive confiscation; we need only assure ourselves that they will be properly used. This result can be attained more quickly and directly by use of the taxing power than in any other way. Taxation is the most powerful weapon for the

redistribution of wealth and income ever devised, and by that token it is the most effective agency for stabilization. All that is required is courage and intelligence in its use.

We can, if we wish, quite simply and easily prevent oversaving, overinvestment, overexpansion of productive capacity, without waiting for this purchasing power to be confiscated by competition, inflation, and deflation in the cycle of boom and depression by taxing away with suitable income surtax rates and inheritance taxes all excess corporate savings and surplus individual income that cannot be spent by the recipients on consumers' goods or replacement of obsolescent equipment, and spending this surplus through governmental channels for the production of free social income by building public works, parks, museums, recreation centers, roads—all of which do not offer commodities or services for competitive sale, and in the building of which purchasing power for other goods is released in wages.

The fascinating prospects and paradoxes opened up by this concept of using the taxing power as an agency of wealth and income distribution and business stabilization—its influence on employment, leisure, industrial activity, and profits, its relation to obsolescence and technological advance, its bearing on economic decentralization, on international trade and finance—are too large and complex to elaborate here. I am fully convinced that no other approach offers quite as simple and certain a way of assuring business stability and rapid rise of living standards in a highly developed country within the capitalistic framework as this. That through centralized industrial planning seems to me largely irrelevant, psychologically impossible, and contrary to fundamental technological tendencies. The approach via credit control is difficult, vague, abstract, uncertain, though ultimately very important. That through fiscal policy is concrete, accurate, and easily amenable to the engineering attitude.

It is useless to indulge in dialectic debate as to whether these lines of approach are socialistic, communistic, or capitalistic. These terms no longer have much concrete significance to me. I personally believe that the ultimate economic organization of society is going to be essentially capitalistic in structure, after a perhaps prolonged period of confused and futile experiment with socialistic centralization and control.

As regards the relation of these terms to stabilization, the essential thing to remember is that the most extreme forms of capitalism and of communism as represented in the United States and in Soviet Russia are essentially the same in this respect: they are both forms of more or less systematic confiscation. The capitalistic organization as it now exists in this country and in Europe can survive only by force of a perfectly definite though disguised process of confiscation of unspendable surplus income or capital for purposes of consumption—partly periodic, partly continuous. This must be true of every highly developed industrial organization. The situation in Russia is just the reverse kind of confiscation—that which was practiced in the early days of this country in a rough way—confiscation of current consumption income for purposes of capital accumulation. Each is suited to the situation. The only question that confronts both is whether each kind of confiscation can or cannot, shall or shall not be made systematic, smooth, and as painless as possible for every one. That is the essence of the issue of stabilization. In neither place has it yet been successfully met.

THE PSYCHOLOGICAL ASPECT OF STABILIZATION

In conclusion, let me touch upon one other aspect of stabilization—to me far more fundamental than any I have mentioned—in which I think that both capitalistic America and Soviet Russia have failed. That is the psychological aspect. However each of these systems may meet the strictly economic problem of balancing consumer purchasing power with production, they must remain, as they now are, essentially unstable systems so long as that problem is met in ways which do not satisfy the instinctive necessities of the individual. We may define those necessities in many ways, for the creative energy of men has many direct and indirect expressions; but the essential necessities are summed up in simplest terms in the complementary concepts of security and freedom. In both systems the emphasis of the economic approach has increasingly come to be on security, to which freedom is being sacrificed; and it is this fact that renders them unstable.

Without carrying the comparison any farther, it is clear to me, at any rate, that capitalism is being transformed more by force of the necessity of offsetting the frustrations of freedom than by the necessity of assuring economic security. At present we stabilizers are preoccupied with the problem of removing the sense of economic insecurity, because we see that it is very disturbing to highly organized and centralized industry. We do not yet recognize that this sense of insecurity itself is only partly and superficially the result of economic unbalance, and that it is the expression of deep-seated and far-reaching frustrations of instinctive necessities of the individual quite as important as his economic needs. We must learn, for example, that the instability of consumer demand which arises from the sense of insecurity is the outcome not only of unemployment but also of employment under modern conditions.

To my mind the greatest promise of the approach to stabilization which I have suggested is that in meeting the problem of economic insecurity it at the same time offers some hope of meeting the other problems of psychological or creative insecurity in a natural and inevitable way which accords with technological tendencies. The same, I am sure, cannot be said of the prevailing concepts of industrial planning. Beneath the superficial symptoms of increasing centralization and concentration of control I believe there is a definite drift toward diffusion of industrial activity which will ultimately emerge in a simpler economic structure, making for greater local self-sufficiency, increased economic activity, increased individual creative satisfaction, and greater stability.

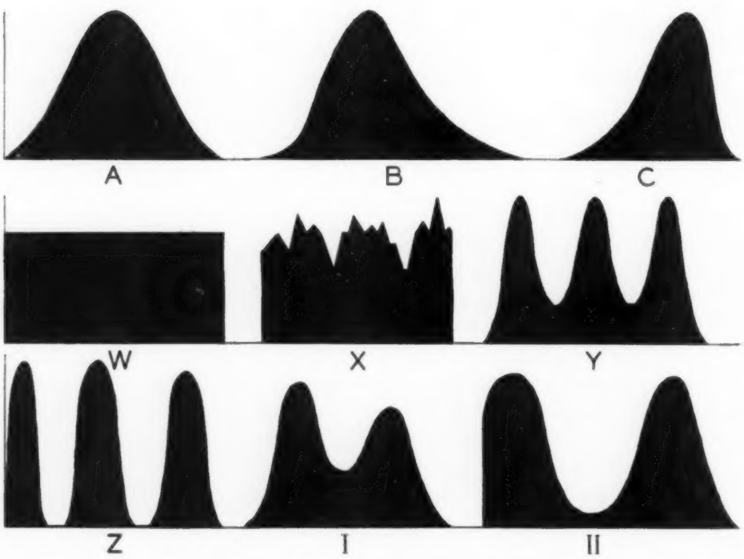


FIG. I VARIATIONS IN DISTRIBUTION OF MENTAL TRAITS

PSYCHOLOGY AND ENGINEERING

The Science of Mind and Behavior, and Its Relation to the Principles and Practices of Human Management

By EDWARD L. THORNDIKE[1]

I OFFER no apology for the topic of this lecture. Mechanical engineers ought to be interested in psychology, the science of human nature and behavior. You are interested in machines. The human mind is a machine, one of the most fascinating machines that any one can study. In spite of the replacement of man power and skill by demons made of steel, it is still the machine that you use most and most widely. You are interested in organization. The human mind is a marvelous organization of knowledge, abilities, interests, wants, and motives. The generators, wires, switchboards, relays, and controls of the American Telephone and Telegraph Company are, I suppose, the most elaborate physical organization that engineering has constructed; yet it is a small and simple thing compared with the organization of a single engineer's mind.

I do not need to argue that if there is a science that is increasing our knowledge of intellect, character, skill, temperament, and personality, engineers who so often are working with and by human material, should profit by it. They should and they will. The question is whether you will learn directly from psychology or indirectly from the advances in practices of management, education, and other forms of human engineering which are due in whole or in part to psychology. I shall try tonight to put you in a position to answer this question, each one for himself. I shall do this, not by any general summary of those parts of psychology which may interest and profit engineers, but by some particular samples.

INDIVIDUAL DIFFERENCES

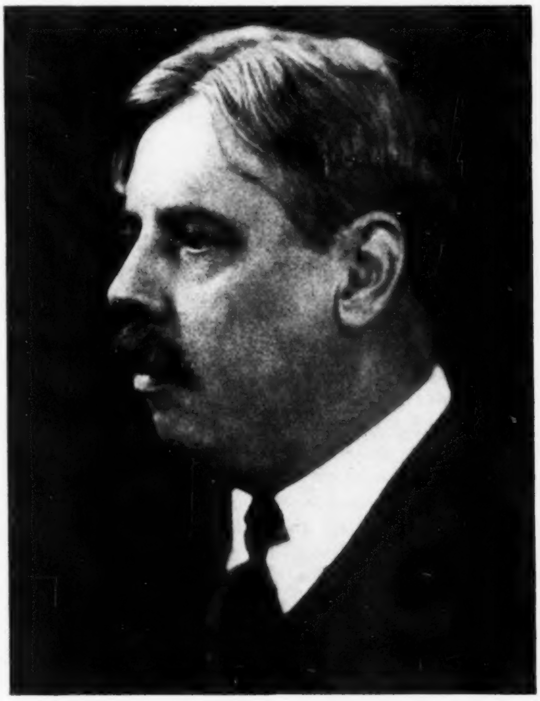
The first of these samples has to do with individual differences. Until about a generation ago the common American doctrine was that these were rare and unimportant. Philosophers described "the mind." Educators planned curricula for "the child." Physicians considered their mental patients as perverse deviates from a "normal" mental condition. Economists assumed that men reacted to labor and to wealth in the uniform pattern of the economic man, avoiding the former with unfailing regularity and appropriating the latter with unerring logic. Religion considered any one soul as equivalent to any other with few exceptions. Moralists encouraged every boy to try to become President. Of course, prejudices of race and caste some-

Third Robert Henry Thurston Lecture on the Relation Between Engineering and Science. Delivered at the Annual Meeting of The American Society of Mechanical Engineers, New York, December 3, 1931.

[1] Professor of Education, Teachers College, Columbia University, New York, N. Y.

times modified this doctrine of a single pattern of human nature plus a few eccentrics, into the doctrine of two or more such patterns.

Beginning with the work of Galton, observations and measurements of individual differences in mental traits have proved that they are ubiquitous and important. And this much knowledge is now, or at least should be, common property. No well-informed employer thinks of labor as a commodity that he may hire and use indiscriminately. No manager should hope to succeed by treating all his clerks or workmen alike. No educator or personnel officer should expect that any career is suitable for all persons who will take the proper training and devote the proper effort to it.



EDWARD L. THORNDIKE

DISTRIBUTION OF MENTAL TRAITS

Psychology studies the nature and magnitude of these differences. They are not chaotic or haphazard. Scores of traits of intellect, character, and skill have been measured objectively and with reasonable precision in large and representative samples of children or adults. Apparently the universal rule or law is that human variations are continuous. From the stupidest idiot to the Aristotles and Newtons there is an infinitesimal gradation in abstract intellect, every place on the scale being filled. Between the weakest memory for, say, tones or nonsense words or colors, and the most tenacious, every intermediate grade occurs. A law almost, or quite, as universal is that the variations cluster about some one amount or degree of the quality or ability, becoming less and less frequent the farther we go up or down from that point on the scale. If the frequencies of different amounts of a trait are plotted as in Fig. 1 by a square of black for each individual above his station on a scale for the trait, we almost always have a result like A or B or C. We never find equality of frequency as in W or fortuity as in X, or rhythmic frequency and infrequency as in Y, or grouping into many distinct species as in Z. Unimodality is the rule. We almost never find bimodality as in I or II.

Equality in the units of such scales can rarely be guaranteed as yet. Many investigators of genius must labor for many years before units for mental abilities comparable to the centimeter, gram, second, volt, ampere, and the like are available. Consequently all laws concerning the distribution of mental traits in man must be somewhat provisional, but in all the cases of which I have knowledge, the more we have improved our units, the stronger the evidence has become for continuity, unimodality, and gradualness of dispersion.

As to causation, this means that the individual variations in most mental traits are due to causes which, in each case, are many in number and small in magnitude, or are relatively independent (that is, little correlated *inter se*), or are many and small and independent. As to practical consequences, it means that classifications of men into distinct groups in respect of any mental trait are almost always erroneous. Language with its adjectives like good and bad, bright and dull, theoretical and practical, scientific and artistic, industrious and lazy, masterful and subservient, which emphasize the two extremes of the scale for a mental trait, misleads us into supposing that there are large actual groupings of individuals near these extremes. On the contrary, mediocrity is far commoner.

I may note here that there are many uniformitarian features of modern life, and particularly of modern industry, which do not fit the variation in human abilities very well; for example, when all have to do certain work at the same rate. Standardization has its obvious advantages, but the genius in factory organization or personnel management who finds ways to harmonize the variety of human nature with efficiency in production would perhaps do a great service. The village community of a thousand years ago could utilize rather fully the varied talents of all its members save those who were very bright. And perhaps we can regain some of its advantages without the loss of our own.

INTERDEPENDENCES OF MENTAL TRAITS

The psychology of the generation past has provided extensive measurements of the interdependences or correlations of many mental traits. Here we plot each person against two scales in a coordinate system, and discover the manner in which, and the closeness to which, status or ability in the one goes with status or ability in the other. Here again exact knowledge must wait for the validation of mental units, but the probabilities are that the line representing the average relation is usually of the form $y = ax + b$. As to the angle which this line makes with the line of perfect interdependence, and the variation of individuals from it, we find, of course, every degree of closeness from identity to zero, or what pure chance would give.

Many traits of intellect, character, skill, temperament, and personality are such that the greater the amount of the trait, the more valuable, other things being equal, the person is to the world. To possess much of the trait is "better" then to possess less, or, at least, is so regarded by the most competent judges, and by people in general. In such cases it is found that the correlations are always, or almost always, positive. To him that hath is given. Nature does not compensate the man with a weak memory by strong power of reasoning, or balance a stupid mind by a cheerful disposition and athletic skill, or penalize virtue by ill health and early death.

As consequences of the linearity of the relations, and the positive correlation of desirables, the distributions of variations in combinations of traits are, as were the distributions of variations in single traits, usually continuous and unimodal; and the most frequent condition is very often at or near mediocrity.

A STEADY, industrious, reliable worker has qualities of intellect and character and skill which are too valuable to be wasted because some industrial change has destroyed the value of the special work which he has been performing. Public or private provision for his education for some suitable work seems highly desirable and likely to cost much less and succeed much more than older notions of adult learning led one to expect.

The possibility and practicability of adult learning will also enable the world to lessen the lag of learning behind science and technology. In the present changing world much that we learn from ten to twenty tends to be out of date when we are forty or fifty. When civilization was more stable and the arts and sciences progressed slowly, it was in general satisfactory for each generation to use during its life what it learned in its teens. But a man of sixty doing so now would be in many respects a nuisance and a danger.... To live well, man must now keep on learning all through life. And this is true in engineering.

EDWARD L. THORNDIKE.

SCHEMES FOR CLASSIFYING MEN INTO DISTINCT TYPES ARE OF DUBIOUS VALUE

All practices in human engineering which rely upon the classification of men into distinct types in respect of composites of qualities or traits are thus of very dubious value. Most of them are fundamentally unsound. Any personnel manager who expects that nature has provided distinct species of men, A, B, C, D, E, etc., fitted to be tip-top as ditch diggers and very inferior at aught else, tip-top as salesmen and very inferior at aught else, tip-top as musicians and very inferior at aught else, and so on, is working on diametrically wrong principles. The task of vocational selection is not solvable by labeling John Doe as Type K29 and finding the job to which Type K29 corresponds. There are few or no such types in human nature, and any such labeling is likely to inhibit the inventory of a person's ratings on a large number of scales, which is the only adequate basis for vocational selection or vocational adjustment.

The fascination of classificatory schemes and the ease of inventing ones that are verbally plausible is so great that even very able men, both among psychiatrists and personnel experts, will probably continue to devise them and advocate them. But the facts indicate that in ninety-nine cases out of a hundred they are doomed to failure.

It is often of very great practical importance to know whether the correlation between two things is direct or indirect. For example, mechanical ingenuity is found to be rather closely correlated with success as a farmer. But we also find, as you will readily believe, that unless the individual is zealous in the regular routine duties of care for his farm implements and plant, this mechanical ingenuity is of very little service toward success as a farmer. Mechanical ingenuity is correlated with such zeal, and owes its apparent potency largely to this indirect connection. Mechanical ingenuity, if it occurred alone, would often lead to useless puttering about the workshop and show a very low correlation with success as a farmer.

HUMAN VARIATIONS AND THEIR INTERCORRELATIONS

Similarly there is a fairly high correlation between amount of education and success in certain lines of business; and this fact is often used as justification for the recommendation, "Stay in school longer and you will make more money in the end." But there are also positive correlations between the stages reached in education (seventh grade, eighth grade, ninth grade, tenth grade, eleventh grade, twelfth grade, or high-school graduation, thirteenth grade, or freshman year in college, fourteenth grade or sophomore year in college, and so on) and certain sorts of intelligence and ambition. Nobody has yet proved that if two thousand boys of 14, alike in intelligence and ambition, were divided into a thousand that then and there went to work, and another thousand that went to work after eight more years of schooling, the latter would in the end make more money.

Such an experiment would be hard to arrange, but the question can be answered without any such experiment by a technique of so-called "partial correlation" much used by psychologists. By it we can know what the effect of one variable upon another would be if it could be freed from the influence of some third variable that is related to both, even though it cannot be segregated experimentally. This technique is destined, in my opinion, to be of wide usefulness in researches in engineering, business, sociology, and government. Its use greatly increases efficiency and economy in tests, rating plans, and the like for selection and promotion in industry.

I wish that I had time to relate the particular facts concerning human variations and their intercorrelations, which seem to me significant for man's control of himself and others. I can mention only two. There is a fairly high correlation, perhaps 0.40, between intellect and morality. The ablest thinkers are thus much above

the average in personal decency, and in good-will and devotion to their fellow-men. Because of this fundamental fact in mental organization, the great intellects of the world have been and are working largely for the common good. Because of it, the dull and incompetent will be better off, even from the point of view of their individual self-interest, to let the able thinkers rule the factories where they work and the communities where they live, than to do so themselves.

There is, apparently, a very low correlation among individuals between achievement and self-approval. That is, the pride and elation and self-respect of a second-rate man at a second-rate achievement are nearly or quite the same as the corresponding feelings in a first-rate man at a first-rate achievement, and neither is very different from the corresponding feelings in very low-grade men at their low-grade achievements. We should not pity or scorn the low-grade man for being restricted to low-grade achievements. We should rather applaud him for doing so well. They do not seem low to him. He is much better satisfied to succeed at making beds or running an elevator than to fail at making dresses or running a trolley car. To make portraits or to run a factory would in most cases make him thoroughly miserable.

We may pity the moron for being a moron, but, if he is one, we should neither pity him for having a moron's work to do, nor excite him to seek a higher sphere.

PSYCHOLOGY OF DIFFERENCES DUE TO AGE

Let us turn now from the psychology of individual differences to the psychology of differences due to age. Childhood, adolescence, maturity, and senescence are characteristic of the mind as of the body. Psychologists have studied especially the early stages of development, and their discoveries have been of influence and benefit in home and school education. But I invite your attention to certain aspects of maturity and senescence.

With the aid of a grant from the Carnegie Corporation a fairly thoroughgoing investigation was made of the ability of young people and adults to learn. Individuals of comparable inborn ability, but varying from 10 years to 42 years in age, were set to learn the same thing under carefully controlled conditions, and the gains made per hour of time spent were measured. The things learned were of various sorts, from so simple and mechanical a task as learning to draw lines of specified length with the eyes closed, to such complex and logical tasks as learning one of the artificial languages (Esperanto or Ido) which are constructed on a rational scientific system with no exceptions. In other instances the things learned were the staple school subjects such as reading, writing, spelling, and arithmetic, and comparisons could be made of the rate of improvement with that made by children learning the same things under ordinary school conditions.

In general, adults of age 42 learn more rapidly than they did as children of 10 or 12. The years from 20 to 30 show better ability to learn than the years from 10 to 20. The ability to learn rises till the early twenties, remains nearly stationary for some years, and then declines at the rate of about 1 per cent per year. Whether this rate of decline increases in the fifties, sixties, and seventies is not yet known. Dr. Terman and Dr. Miles are now at work studying these later stages and we soon shall know. We know enough at the present time to be certain that it is not lack of ability to learn which makes so many of us stop learning in adult years.

The relevance of these facts to the problem of technological unemployment is clear. Industry may face changes in machinery, processes, and the like with the the hope of reducing the disturbance by educating the displaced workers. I am confident that the hand weavers who were thrown out of employment by the invention of the power loom could in many cases have been taught not only to use the power looms, but also to make them and repair them, or to be useful in whatever factory work or trades were short of employees at the time. A steady, industrious, reliable worker has qualities of intellect and character and skill which are too valuable to be wasted because some industrial change has destroyed the value of the special work which he has been performing. Public or private provision for his education for some suitable work seems highly desirable and likely to cost much less and succeed much more than older notions of adult learning led one to expect.

POSSIBILITIES OF ADULT LEARNING

The possibility and practicability of adult learning will also enable the world to lessen the lag of learning behind science and technology. In the present changing world much that we learn from ten to twenty tends to be out of date when we are forty or fifty. When civilization was more stable and the arts and sciences progressed slowly, it was in general satisfactory for each generation to use during its life what it learned in its teens. But a man of sixty doing so now would be in many respects a nuisance and a danger. He would be, for instance, unable to drive our commonest vehicle or to turn on and off the commonest form of light or avail himself of our commonest means of entertainment. He would endanger life by neglecting essential sanitary precautions. A large fraction of the customs and beliefs of the young people of today would be incomprehensible or odious to him. To live well, man must now keep on learning all through life. And this is true in engineering.

In a changing world, learning at all ages becomes more and more important, and my next sample from psychology concerns one feature of learning in general, namely, the effects of reward and of punishment upon learning. You should, I think, be interested in this in relation to the adjustment of workers to their work, which is coordinate with the selection of workers for various sorts of work. I hope you will be interested in it also in its wider bearings.

REWARDS AND PUNISHMENTS

The usual theory about rewards and punishments has been that a reward attached to a tendency strengthened that tendency, and that a punishment attached to a tendency weakened it. The usual practice with rewards and punishments has been to use either. If you wanted to make a person more likely to do one thing, call it A, and less likely to do another thing, call it Z, you would reward A or punish Z. Reward and punishment have been thought of and treated as opposites.

In the Institute of Educational Research of Teachers College, we have been doing some experiments to find out just what rewards and punishments really do do. The results are extraordinary and seem to be of far-reaching significance. The general plan of all the experiments is the same. In every case the person may do any one of several things, of which one is right and the rest wrong. If he does the right thing, he is then and there rewarded. If he does the wrong thing, he is then and there punished. For illustration here I will take cases where there are five acts possible. Call them R (the right one) and X1, X2, X3, and X4 (the four wrong ones). For example, I show the person a German word followed by five English words, one of which is the correct translation, the other four being wrong. He chooses one of the five, and is rewarded if it is right and punished if it is wrong. We do the same for 199 other German words, and then repeat the 200, and so on until many or all are learned.

The extraordinary result is that in such cases the punishments do no good whatever. Punishing X1, or X2, or X3, or X4 does not make it less likely to occur. The person improves only because of the rewards for R. If the person does R and is rewarded he is more likely to do R the next time. But if he does X1 and is punished, he is not less likely to do X1 the next time. The wrong tendencies are not reduced in strength one jot or tittle by the punishment. If the person gets rid of them, it is simply and solely because the R tendency becomes so strong that it displaces X1, X2, X3, and X4. All the improvement in these experiments is due to the rewards.

PUNISHMENT NOT A TRUE OPPOSITE OF REWARD

These and other experiments prove that punishment is not a true opposite of reward. Where reward strengthens, punishment will not necessarily weaken. Rewards may do much where punishment does nothing useful. The experiments lead me to believe that the value of punishments has been much exaggerated in both theory and practice.

The value of a punishment has been supposed to lie in its general weakening effect upon the tendency to which it is attached. I expect our further experiments to prove that it has no such general weakening effect, that it will be effective only in certain limited circumstances and under certain limited conditions. Rewards, on the contrary, do have a strengthening effect that is general, and perhaps universal.

These facts are important, because in homes, in schools, in business, in government, and even in religion the world has been relying on punishment as much as on reward, probably more.

Consider Kuo and his rats. Kuo made a chamber with four passageways leading from it. If a rat entered the first passageway, it received an electric shock that made it squeal. If it entered the second, it was confined in a little cell for 30 seconds. If it entered the third or fourth, it was fed. The rats learned to choose the right passageways, and Kuo considered that the punishment for entering the wrong ones was necessary. But I can show that the punishments had very little if anything to do with it.

We have been like Kuo. We have thought that our fines and beatings and jails and electrocutions cure men of evil tendencies, when the real power lies in the rewards (of public esteem, self-respect and the like) for decent behavior. We often do worse than Kuo. We scold and beat children and shut men up in cells for wrong-doing, but never reward them when they keep the peace and serve mankind.

In our experiments we found that much the best way to eradicate a bad tendency was to put a good tendency in its place and reward it. I believe we should try this way oftener in homes, schools, business, and government.

Psychology should be a science fundamental to all branches of human engineering, as physics and chemistry are fundamental to all branches of material engineering. Psychologists are working to make it so, but for the present we realize that we have much more to learn from the other sciences of man than to teach them. This lecture might well have been devoted to a recital of what psychology may learn from the principles and practices of human management which engineers and other directors of large enterprises have devised. But it seemed more profitable to leave that for some engineer to do in a lecture to psychologists.

OTHERS have said that man is an animal who laughs and cooks his own food, man is an animal who desires company at his meals, man is an animal who can count more than three, man is an animal who can repent. That is all very good, but it is not all; man is an animal who makes the tools which he uses. Man "has resisted every temptation to specialize his hand in the various directions in which it has been differentiated throughout the vertebrate series; he has retained the simple pentadactylous hand of his amphibious ancestors," yielding only so far as to tip it with fragile horn. Which was the first tool that he used for making tools? Without doubt it was the hammer. The earliest implements were flint scrapers with which a beast was skinned, or wood was shaped for use. And the making of the flint scraper required force provided by stored energy—by a hammer blow in fine. I claim it as true, then, that mechanical history began with the hammer.—Lt-Col. E. Kitson Clark in I.M.E. Presidential Address, London, Oct. 23, 1931.

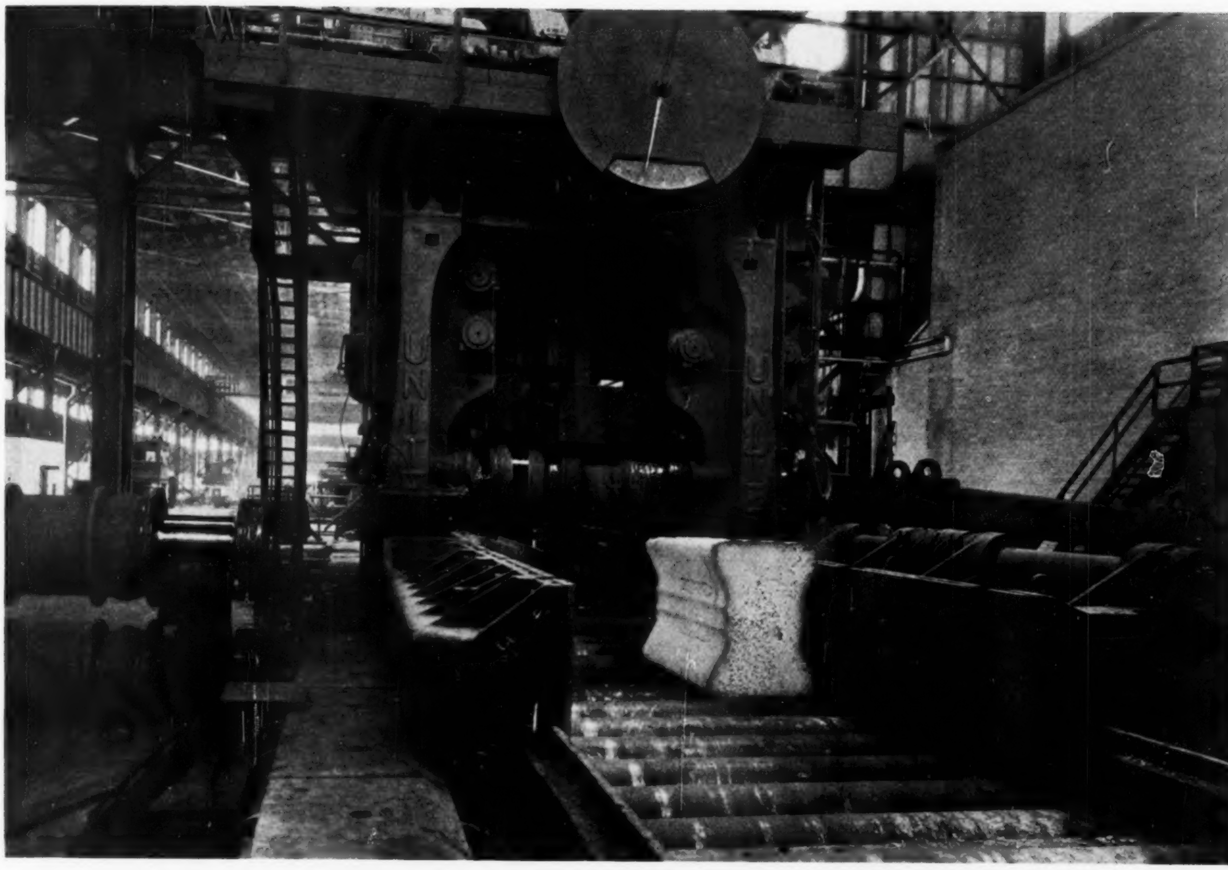


FIG. 1 SHOWING 18-TON INGOT ENTERING ROLLS OF 54-IN. BLOOMING MILL AT SOUTH CHICAGO PLANT OF THE ILLINOIS STEEL COMPANY

MODERNIZING THE STEEL MILL

Outstanding Improvements Effected at the South Chicago Plant of the Illinois Steel Company

WHAT has been and is now the attitude taken by such a major industry as steel with respect to the current depression? Facts speak louder than words, and at the outset of the present investigation it was decided not to ask for opinions regarding the present economic situation and its future tendencies, but rather to collect such facts as might be available, and from them draw a conclusion. It was felt that if the leaders of the steel industry are convinced that we are now approaching the up-slope of the economic-cycle valley and if they really believe that substantial improvement is in sight, this would be indicated by their spending money to get ready for coming business. With the industry operating at the time of this writing at an average rate of about 30 per cent of capacity and with but one or two districts (Cleveland and Youngstown) exceeding that average—by about 5 to 10 per cent—there is evidently no call for additional investment to take care of present production.

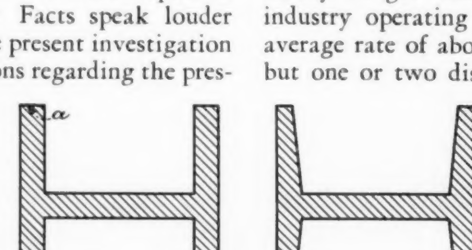


FIG. 2 CROSS-SECTIONS OF WIDE-FLANGE BEAM AND ORDINARY H-BEAM

Any new expenditure for plant improvement, therefore, represents that much faith in the future of the country in general and the steel industry in particular.

In this connection it will be recalled that there was a practically complete cessation of all new construction following the panic of 1907, and an equally drastic reduction of new installations during the deflation period of 1921–1922. With these facts in mind it seemed that an investigation of what the major units of the steel industry are doing would give a fairly reliable indication of what leaders of the nation's business feel about the chances of the next few years, not when they are talking for publication, but when they have to approve expenditures of large amounts of money.

Briefly, it has been found that throughout the industry an earnest effort is being made to improve the quality of products, to put out new products where there is a market for them, and above all to cut the costs of production to the limit by reorganizing processes of manufacture and, where necessary, installing new machinery. This is due partly, of course, to a factor which, at least in so far as the steel industry is concerned, was not prominent in either 1907 or 1921, namely, the rapidity with which improvements in machinery and methods nowadays affect the plant situation.

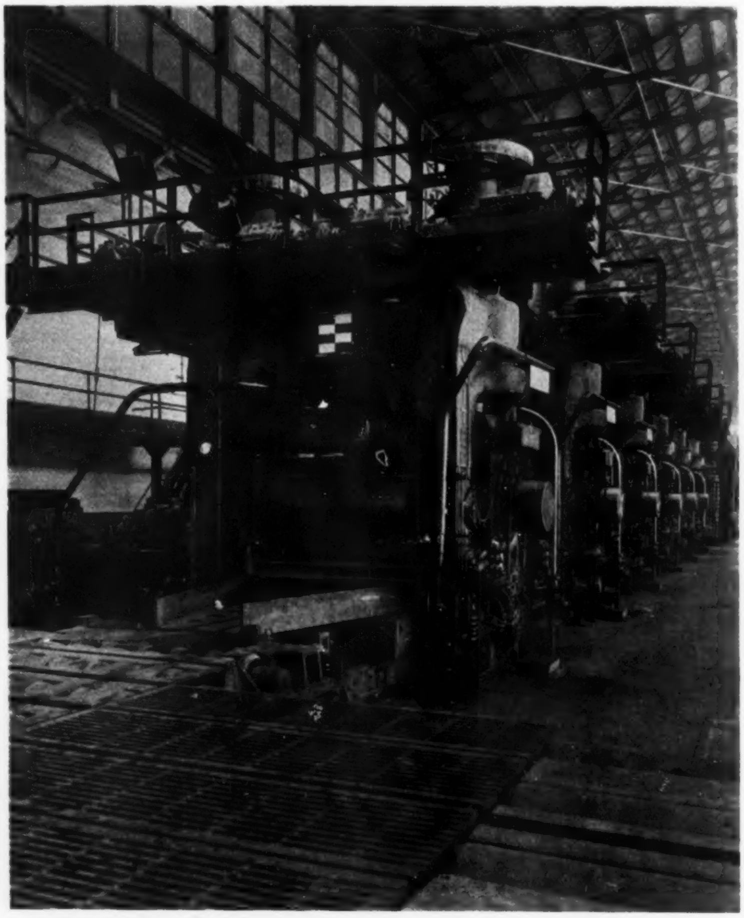


FIG. 3 FINISHING STANDS OF 96-IN. PLATE MILL

Up to a few years ago the large steel companies carried on practically no research. Invention of new machinery within the company was tolerated, but not considered as an essential part of the work. All invention and development work was carried on outside, primarily by concerns supplying equipment to the steel companies, and was paid for by the latter as part of the cost of the machinery. Practically all developments were therefore available, at a price, to the entire steel industry, and as a matter of fact there was very little difference between the methods of production and apparatus used by the various companies. This is of course merely a general statement, and is not intended to cover every feature of production.

Within the last few years the situation has changed entirely. Practically all the steel companies have gone into research and development work on a substantial scale, while the amount of such work outside the industry has become enormous. The result is that the steel companies are now somewhat in the position of Alice in "Through the Looking Glass." Alice was asked to take part in a race, and shortly after starting, stopped and told the Queen that she was not going to continue, because, no matter how fast she and her competitors ran, they did not get anywhere. The Queen told Alice that in her country a person had to run as fast as she could just to keep where she was. That is exactly what the steel industry has to do today. Sheet manufacture is a good illustration. Up to a few years ago every one made sheet by the same method and with the same machinery. Sheet was expensive, but so long as it cost every one the same to make it, high production cost did not enter as a competitive factor. Then came the continuous sheet-rolling process, giving a considerable advantage in the cost of production, with the result that, for example, the Inland Steel Company found that it had either to install a continuous sheet mill or practically go out of the sheet business. Such a mill is being built at its Indiana Harbor plant in the midst of the present depression at a possible cost of construction of $10,000,000. The same applies, on a less impressive scale, to a number of other developments which have to be carried out if only in order to maintain a competitive position in the industry.

DEPRESSION SUNSHINE

Those who long to see brightness in the present overcast industrial skies do not lack indications that it is near at hand. Engineers, however, may be interested in another manifestation of effulgence. Nowadays the

sun is shining over Pittsburgh and Chicago with a brilliancy and regularity beyond anything "within the memory of the oldest inhabitant." There are some indications that this splendid weather is a direct result of the present industrial depression, and if so, the fact may be of interest to students of the air-pollution problem. The smokestacks of the steel mills, glass works, and brick kilns are no longer belching forth the huge clouds of black smoke that are normally a feature of mill towns throughout the Middle West. They are not using as much fuel as they do in normal times because of the reduction in the total volume of business, and what fuel is being used in steel mills practically comes in the form of gas (and some tar) from the blast furnaces and coke ovens. This is a practically smokeless fuel, and does not contain those particles of carbon and solid matter which apparently are an essential feature in the formation of fog and clouds. The electrical mechanism which turns the solid matter projected from the smokestacks into nuclei for the formation of fog and clouds is, of course, fairly familiar. Now that the air is pure, or relatively so, the sun is shining. May it be hoped that the day is coming when it will not be necessary to have an industrial depression with all its accompanying evils in order to obtain the decent weather conditions which are so valuable to the health and happiness of our population!

General Features of the Illinois Steel Company's South Chicago Mill

The South Chicago plant of the Illinois Steel Company is one of the very large mills typical of the latest American methods of mass production. It is not so well known and not quite so large as the Gary plant of the same company, which is a subsidiary of the United States Steel Corporation, but its production in every department is large enough to justify the adoption of the best modern machinery and plant-operating improvements. A complete description of the South Chicago plant would require a sizable book, and in consequence only some of the outstanding novelties of construction carried out within the last few years can be described here. Of course, not all of the recent developments are of the same importance. One of the most prominent of these is the wide-flange-beam mill which introduced a new product, as well as a new method of manufacturing. The ordinary H-beam, Fig. 2 (right), had a taper on the inner faces of the flanges. In some cases the presence of this taper was harmless, while in other cases it was objectionable. The reason for using the taper was of course that it facilitated the rolling of the shape. The ordinary H-beam was rolled from a rectangular billet, which was gradually squeezed by tapered rolls until it attained the proper shape. Because of the taper employed there was no trouble from the work's gripping the rolls.

In the rolling of the wide-flange beam the start is made with a billet of some such shape as that shown in Fig. 1. The mill consists of three sets of rolls; one, a driven set, acts on what would correspond to the horizontal bar or web in the H. The effect of these rolls is first to deepen the H-section of the original billet and to reduce the web to the proper thickness. These rolls, of course, take the largest amount of power. Next there is a pair of vertical rolls corresponding to the vertical rolls in a universal mill, with certain differences, however, which will be explained later. This pair of rolls is not driven. The third pair of rolls are the edging rolls working on the flanges of the beam (*a*, Fig. 2). These rolls are not driven, and while the amount of work which they do is not very large, it is nevertheless very important in that it results in producing a beam with the edges square with the axis of the cross-section.

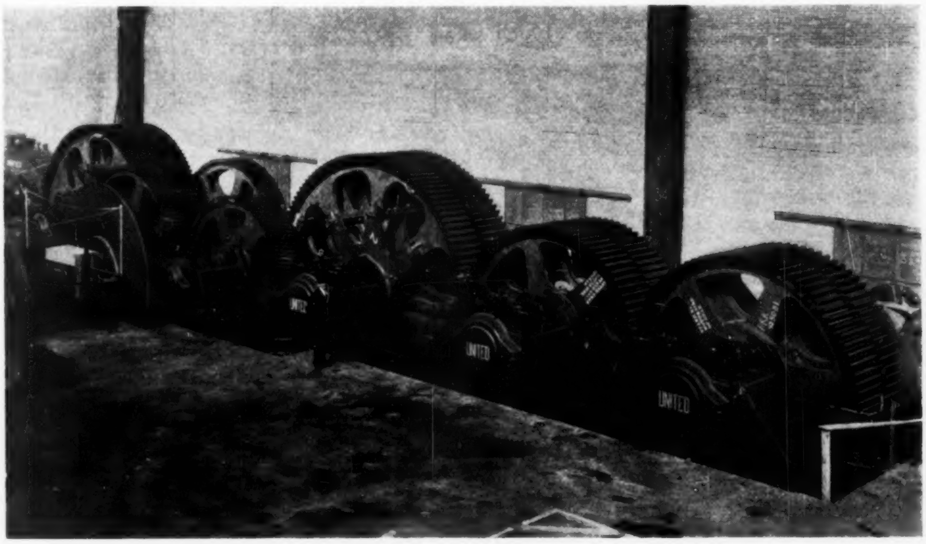


Fig. 4 Special reduction-gear drive for roughing rolls of 96-in. plate mill

When understood, the problem of rolling a wide-flange beam is comparatively simple with one exception, and that is that obviously, in order to obtain the best results, the amounts of reduction in each direction must be very carefully proportioned. This means that what is known as the amount of screwdown, positive or negative, of each set of rolls must be exactly right. The matter is still more complicated by the fact that in this case we have both positive and negative screwdown, since while the main horizontal rolls come closer together as the rolling proceeds, the vertical rolls

move away from each other. Had the old system of hand-operated screwdowns been employed, every adjustment of the rolls for a succeeding pass would have taken considerable time and involved considerable uncertainty due to the human element. It would have been very difficult to secure an exactly uniform movement of the rolls for each pass, and an exact coordination between the three sets of rolls. This problem has been solved at South Chicago by the employment of electrically controlled screwdowns. Each of the three sets of rolls is controlled by a motor of its own, while the operations of the motors are controlled from three sets of adjustable contacts, each enclosed in a fixture about 6 ft high and 3 ft in diameter. The entire operation is controlled from the pulpit where the master roller is located. All that he has to do is to throw a switch, which operates a motor on each of the sets of contacts and moves the contacting point through a predetermined distance in each set. This causes the motors operating the actual screwdowns on the rolls to move a similarly predetermined distance, and automatically insures that the amount of screwdown for each pass in each set of rolls will be exactly alike for each operation. The motors operating the contacting points have, of course, to be reset for each size of beam rolled, which is a comparatively simple matter as tables of proper settings have been worked out.

This method of controlling screwdowns is illustrative of the most modern tendencies in steel rolling. Not only is there a saving in the cost of labor since one master roller replaces four men, but what is more important, a uniformity of product is obtained which would have probably been impossible with three men on the screwdowns, each of varying psychological character and therefore of varying capacity in his methods of working and judgment. Moreover the operation of screwdowns by means of the electrical devices employed is, in addition to being more reliable and uniform, much more rapid, thus permitting a greater output from the mill. This, in turn, is a matter of considerable importance where the mill is very large and expensive, and therefore a substantial amount of fixed charges, such as interest and depreciation, must be charged to each hour of time, whether or not the mill is in operation.

THE PLATE MILL

The new plate mill completed comparatively recently is really a huge affair. To begin with, it had to be located on the site of a former slag dump. Excavating in such terrain is a difficult task in itself, and to perform it with the speed with which it was accomplished in this case required at certain times the services of as many as twenty steam shovels. The mill itself, Fig. 3, is very nearly three-quarters of a mile long and consists of three roughing and six finishing stands capable of rolling plate from $^1/_8$ in. to $1^1/_4$ in. thick. The three roughing stands are driven by a 4000-hp motor through a set of gears which are notable even in present practice for their enormous size. (See Fig. 4.)

The finishing stands are driven by individual motors, as also are the run-out tables. It may be noted in this connection that a person going through a modern mill does not realize, unless he looks beneath the surface, how much expensive machinery is necessary for its operation. A large share of the cost of the mill is hidden underground in the form of motors, drives, etc., not counting the mill foundations and excavation work, which in this case, for example, have been a very expensive item.

The slab which forms the raw material for the present mill has first to be freed from scale. To do this it is passed through a set of scale-breaking rolls, and at two other places in the course of rolling the plate is subjected to the action of a jet of water delivered under a pressure of 1000 lb per sq in. With the primary scale cracked under the scale-breaking rolls, the jet of water gets beneath the scale and rips it off. The same procedure is followed in dealing with the secondary scale which forms during the rolling itself. This scale is less adherent than the ordinary scale, and therefore chips off more easily under the powerful action of the jet of water. Incidentally the drop in temperature during rolling is comparatively small, and is estimated at about 100 F per pass. This small loss is due to the fact that while the straight loss from the metal to the ambient medium by conduction, convection, and radiation is quite large, particularly where the water acts on the metal, a considerable amount of heat is put back into the metal by the mechanical work of rolling.

As the run-out beds are not long enough to accommodate the entire piece for purposes of shearing, the plate is cut into three pieces, each somewhat longer than the desired finished dimension. These pieces are then sheared, and next cut to size. This involves, of course, a slight additional loss, which, however, is not a competitive feature as this method of shearing is common to all mills of this type. As a whole the mill gives a pleasing impression because of its neat design and the absence of cumbersome mechanism, due to completely electrified drive.

THE BLOOMING-MILL DRIVE

The conventional method of driving a blooming mill, one of the heaviest power consumers encountered in a steel mill, is through a motor driving one roll, usually the bottom one, from which, through a pair of pinions, the drive is transferred to the top roll (Fig. 5). Certain disadvantages of such a drive have long been recognized, but it is only recently that it has become possible to substitute for it such a drive as that employed at the South Chicago plant of the Illinois Steel Company where both rolls are driven from independent motors, no gearing between the rolls being employed.

To make such a drive possible it was necessary to devise a control of the motor speed that would be precise within a comparatively small fraction of a revolution, as it is only with the two rolls running at substantially the same speed that the operation of the mill becomes possible. In this case the driving motors are

variable-speed d.c., fed from a motor-generator set, the variations of speed being effected by voltage control. The shaft driving the top roll is equipped with a thrust bearing, and both shafts run in roller bearings provided with forced-feed lubrication.

One of the features of this installation is that all the air going to the motor room is constantly recirculated and washed, with the result that neither the original air nor the make-up air carries any appreciable amount of dust. This arrangement not only appreciably increases the life of the motors, but makes the conditions of working pleasanter and healthier. All the oil used for lubrication is recirculated and cooled. The air pumps and cleaners and the oil coolers are located in a basement under the motor floor, and are out of the way of the operating force.

Among the minor mechanical improvements on the floor where the blooming mill and the wide-flange-beam mill machinery are located, may be mentioned a novel type of shear. In this case the shear is operated by two motors, the first, a comparatively small d.c. motor, bringing it up to speed while it is running idle. The working motor, which is an a.c. machine, then takes the shear away from the d.c. motor and provides the power for the actual cutting. The advantages of such an arrangement are that a large proportion of the shock is eliminated and better work is produced. The principle is essentially the same as that involved in an automobile starter working through a Bendix drive, the starting motor spinning the engine at a speed necessary to produce ignition of the fuel, whereupon the engine takes itself away from the motor by running at a higher speed.

WASTE-HEAT BOILERS

The question of power generation does not matter much at the present time with the mills operating at 30 to 35 per cent of capacity. When they are operating, however, at or near full load, it becomes important.

From general information obtained throughout the steel-mill district, and which applies more or less to all mills, the cost of power in large modern steel mills is of the order of $1/2$ cent per kwh. This is, however, largely a bookkeeping figure, because the gas from blast furnaces and coke ovens consumed under boilers and the heat from waste-heat boilers on open-hearth furnaces are charged to the power-generation plant. As matters stand today, all of this gas and heat would be lost if it were not utilized in the generation of power. And until the time when other uses shall have been found for the energy available from these sources, it may be contended that its value should not be charged to the kilowatt-hours produced, which would bring the cost of the latter down to a very small amount indeed.

The use of waste-heat boilers on open-hearth furnaces has become quite extensive of late. At South Chicago the most recent installation comprises fourteen boilers on the open-hearth furnaces of plant No. 4. These are B. & W. boilers in which the main boiler is full of water all the time and which have a steam drum on top. They operate at 225 lb pressure, and are provided with an exhaust fan on the discharge side.

GENERAL IMPROVEMENTS

These have been going on in two directions, and only a few can be mentioned here for lack of space. In the first place, an earnest effort has been made to take all guesswork out of the operation of the plant. One of the factors affecting the efficiency of an open-hearth furnace has been the control of the reversal of the regenerator valves. In an open-hearth furnace, gas of a comparatively low heating value is used, and yet an extremely high temperature must be produced. This problem was solved by Siemens many years ago by the use of regenerators. These in effect are two chambers filled with firebrick checkerwork, through which either the exhaust gases from the furnace or the heating gas may be directed in accordance with the setting of so-called reversing valves.

Exhaust gases passing for a certain time through one of these chambers heat the checkerwork, and when the valves are reversed and the fuel gas is directed through the same checkerwork the gas is preheated to such an extent that it becomes capable of developing the high temperatures required in the furnace.

Hitherto the reversal of the valves has been effected more or less indiscriminately. The usual practice has been to reverse the valves every 15 or 20 minutes, which served to run the furnace but apparently did not insure the best economy in fuel. Lately at some plants, including the South Chicago works, pyrometers have been put on the regenerator checkerwork, with the result that the reversal of the gas valves is now effected when the brickwork is at the right temperature, which means when it has cooled to the desired extent. The result is that a more uniform operation of the furnace and economy in the consumption of fuel are obtained. The steel-mill engineers in describing this new installation predict that the day is not far off when the pyrometer will be hooked on or converted into a thermostatic device which will reverse the valves automatically when proper temperature conditions have been attained. This effort to conserve fuel is evident throughout the mill. Quite recently, for example, a gas line has been installed from the blast furnaces to the reheating furnaces on the rolling mills and soaking pits on the blooming mill. Here again we are told that the day may come when waste gases from other processes around the steel mill will be used to heat the open-hearth furnaces. The time has not yet arrived, however, for that. The blast-furnace gas may be used in reheating furnaces and soaking pits either as such or enriched by tar injections.

Another addition to the mill within the last year is its big sintering plant. The dust from blast furnaces contains a considerable amount of fine material with a high metallic content. Until recently it was permitted to escape into the atmosphere, and gave that gray appearance to the landscape which was formerly typical of mill towns. This practice would not be tolerated

nowadays and various methods are being employed to catch the fine dust, the electrical precipitation method being the one favored at the South Chicago plant. The result of its application is the collection of considerable amounts of fine dust having, as has been stated above, a high metallic content. The purpose of the sintering plant is to convert this dust into a material that can be returned to the blast furnace. In this way two important purposes are accomplished. In the first place, what would have been a waste is now converted into a useful material, and secondly, the troublesome disposal of a waste as difficult to handle as very fine dust is eliminated. Incidentally, the presence of fine dust in ore is now less important than it would have been had no method of usefully recovering it been installed.

Looking over the whole situation at the South Chicago plant, the following striking features become evident. In the first place, there is no spirit of despondency visible as a result of the present industrial depression. Not only is there no policy of suspending all work of improvement and new installations, but several important projects have been carried out since the time when the depression became evident. Among these may be mentioned the blast-furnace gas line, the sintering plant, the installation of waste-heat boilers on the fourteen open-hearth furnaces of plant No. 4, the installation of the large mill for rolling wide-flange beams, etc.

The next thing that deserves particular attention is the tendency in the control of product to get away from the influence of the human factor. This is strikingly illustrated by such things as the installation of pyrometers on the checkerwork of the open-hearth regenerators, the installation of automotive electrical control of screwdowns on the wide-flange-beam mill, and the multitude of meters and indicating devices of all kinds.

Like all big mills of today, the South Chicago plant is thoroughly electrified. It was only this electrification that permitted such departures from standard practice as, for example, the drive of the two rolls of the blooming mill by individual motors. Considering the enormous amount of energy required by such rolls, the ability of the motors to keep in step with each other is something that would have been considered impossible only a year or two ago. It is a very striking illustration of the high degree of progress which has been already achieved in the application of electrical controls, and bears promise of a further extension of the principle of synchronization of moving parts, not by rigid gear connection as formerly, but by electrical interlocking only, with all the consequent benefits of saving of space, smaller chance of breakages, and apparently highly reliable operation.

If there is one thing certain it is that the old-fashioned steel mill where steel was made in the sweat of the brow has definitely gone, and few will regret its passing. It was a dark and dangerous place. The day when there was no accident was considered somewhat exceptional, particularly in such departments as rod mills. The work was done in a crude and haphazard manner, with the foreman's eye as the main reliance for the control of production. The working day was twelve hours long, and twenty-four hour shifts were not uncommon.

One could not help thinking of those days as one passed through mill after mill of the South Chicago plant of the Illinois Steel Company, where all the gears are guarded, accidents have been reduced to a minimum, the eight-hour day is the rule, and the innumerable meters, pyrometers, and indicators of all kinds have taken the guess out of steel manufacture and are tending to reduce it to an exact science. Of course, the Illinois Steel Company is not the only one that is characterized by these advances.

The present article would have been impossible without full cooperation on the part of the steel companies involved, and in this instance such cooperation was unstintedly provided both by the authorities of the Illinois Steel Company in Chicago and the management of its South Chicago works, and is gratefully acknowledged.

It is hoped to publish later articles dealing with other aspects of the steel industry and with other basic industries.

FIG. 5 MOTORS FOR 54-IN. BLOOMING MILL

FIG. 1 NEW YORK CITY SUBWAY CARS HAVE FOUR DOOR OPENINGS ON EACH SIDE

IMPROVED RAPID-TRANSIT CARS[1]

Light-Weight, Quick-Loading Units for New York's New Subway

THE development of a car best suited to meet the traffic conditions of the Eighth Avenue subway and connecting lines, New York City, required much investigation and research work. Studies were made of various elements limiting the number of trains per hour, which elements determine the capacity of the line. Any run of a train may be divided into five periods: (1) acceleration, (2) running with full potential applied to the motors, (3) coasting, (4) braking, and (5) station stop. Accelerating and braking rates of $1^3/_4$ and 2 mph per sec, respectively, were selected as amply efficient and as they could also be used without discomfort to passengers. The period of operation with full voltage applied to the motors is regulated by the characteristics of the motor. Coasting is a function of the road profile, the internal friction of the train, and distance between stations. The shortening of station stops appeared particularly to offer a means of speeding up operation.

Studies of the time of station stops were made at Times Square and Grand Central, two congested I.R.T. stations, and at several points on the B.M.T. lines. Data were collected on the speed of loading and unloading, of opening and closing doors, and other factors affecting length of station stop. It was found that with all the cars in use at present the distribution of traffic between doors is not equal. With the I.R.T. cars more passengers use the center doors than either of the end doors, with the B.M.T. 67-ft cars the end side doors have heavier traffic than the center doors. It was found that much benefit would result from an increase in the number of doors—but the greater the number of doors the less the number of seats, unless seats are disposed down the center of the car. Many studies were made of such a seating arrangement, but it was considered too highly experimental to adopt for the large number of cars involved. Using normal seating arrangements, studies were made of cars with four, five, and six doors on each side of the car. These seated 60, 52, and 48

[1] The designing and engineering work on this equipment was done by the engineering force of the Board of Transportation, New York City, of which Robert Ridgway is Chief Engineer, John R. Slattery, Deputy Chief Engineer, Harry N. Latey, Chief Electrical Engineer, and John O. Madison, Engineer of Shops. This article has been arranged from information furnished by these engineers.

FIG. 2 THE WIDE CENTER AISLE ASSISTS IN RAPID UNLOADING AND LOADING

passengers, respectively. It was ultimately decided to construct cars seating 60 passengers with four doors on each side, and with doors located so that one-fourth of the maximum number of passengers would be in the zone of each door. Approximately the same number of passengers should use each door, thus reducing the time for unloading and loading.

Studies were also made of different-width door openings and with single and double doors. A double door requires only about half the time for opening and closing that an equivalent single door does, and because of its decreased weight it is easier to accelerate and retard. Also, having a smaller moving mass, the blow received by a passenger standing in the doorway is reduced. The new cars have double doors of aluminum, the door opening being 3 ft 10 in. wide. Flexible edges are provided, and the bottom is notched so that a passenger's foot may be easily withdrawn after the door is fully closed.

NO POSTS OR DIVISIONS AT DOORS

It was also decided that the door opening should be free from posts or divisions since such obstructions reduce the capacity of the door and, as they furnish a convenient anchorage for standing passengers near the doorway, prevent the ready movement of those wishing to get off or on the car.

As a result of these studies constants were determined by means of which the following estimate was made for the new cars, the I.R.T. cars, and the B.M.T. 67-ft cars operating through a congested station like Grand Central:

	New cars	B.M.T. 67-ft car	I.R.T. subway car
Number of trains per hour.....	33.2	30.7	29.7

There should thus be a gain of about 12 per cent in train capacity over I.R.T. equipment resulting from the new arrangement of doors.

CAPACITY PROVIDED FOR TRANSPORTING 92,960 PASSENGERS PER HOUR

The maximum length of train to be operated received much consideration. With present improvements in multiple-unit control there seems to be no reason why trains of 15 or 20 cars each cannot be operated. However, the public demands that stations be quite close together. This makes the operation of long trains difficult, and, under some conditions, results in lower line capacity if a certain length of train is exceeded. Present designs call for the operation of ten 60-ft cars per train normally, with provision for an increase to eleven cars if found desirable.

At present the I.R.T. trains are limited to ten cars, with a maximum load of 2000 passengers. The B.M.T. trains are limited to eight 67-ft cars, or 2400 passengers per train. The new lines with trains of ten 60-ft cars will have a train capacity of 2800 passengers. With the numbers of trains per hour as given in the preceding paragraph, the maximum capacities in passengers per hour will be: 92,960 for the city lines, 73,680 for the B.M.T., and 59,400 for the I.R.T., or for the city lines an increase of more than 56 per cent over the I.R.T. capacity.

A total of 300 cars were constructed for the initial operation. Some details of dimensions, weights, and equipment are given in Table 1. Light weight was an important consideration throughout the design. Car weight affects operating costs, and the wheel loads were limited to those that are permitted on the river bridges. It was considered essential for passengers to be able to walk from one car to another without danger, even while operating around the shortest curve, so the overhang of the ends of the car body from the center of the trucks

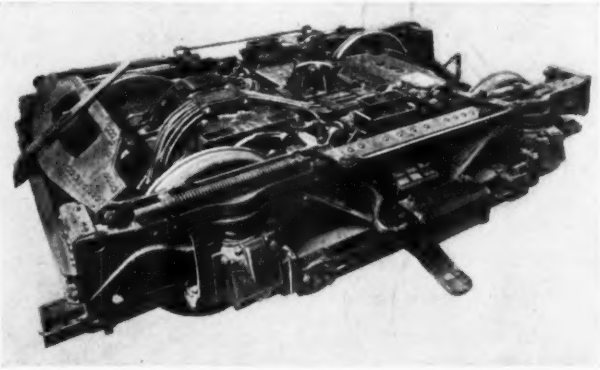


FIG. 3 ONE OF THE MOTOR TRUCKS COMPLETELY EQUIPPED

TABLE 1 DIMENSIONS, WEIGHTS, AND EQUIPMENT OF NEW YORK CITY SUBWAY CARS

Number of seated passengers per car	60
Total seated and standing passengers per car	280
Number of motors per car	2
Horsepower, each motor	190
Average schedule speeds:	
Local service, mph	16.6
Express service, mph	24.6
Wheel diameters, new:	
Motor trucks, in.	34¹/₄
Trailer trucks, in.	31¹/₄
Length over anticlimber edges	60 ft 2¹/₂ in.
Length over coupler faces	60 ft 6 in.
Width overall	10 ft 0 in.
Height, rail to roof	12 ft 2 in.
Bolster centers	44 ft 7 in.
Truck wheelbases:	
Motor trucks	7 ft 0 in.
Trailer trucks	6 ft 3 in.
Weights in pounds:	
Car body, steel	21,218
Floor covering (Tucolith)	1,956
Body equipment	19,766
Trim, sash, doors, etc.	5,360
Car body, completely equipped	48,300
Motor truck (with gears)	14,100
Two motors (less gears)	10,000
Trailer truck	11,900
Total weight of car, empty	84,300
280 passengers at 140 lb	39,200
Total weight of car, loaded	123,500

was reduced to 7 ft 9³/₄ in. This brought the trucks of adjacent cars closer together, and so reduced the length over which the wheel loads were distributed, and thus increased the necessity for weight economy.

TWO DRIVING MOTORS MOUNTED ON ONE TRUCK

Another feature that affected weight distribution was the decision to mount the two driving motors on one truck. With this arrangement maintenance of the motors is easier and less expensive as it is necessary to remove but one truck for overhauling. It was also felt that a balanced distribution of mass in center-bearing trucks, such as results from this arrangement, would reduce nosing, that is, the tendency toward side swaying. It is thus possible to have two motor trucks adjoining each other, and as each of these trucks with its motors weigh 12,200 lb more than a trailing truck, there is in such a case quite a heavy load for distribution over a

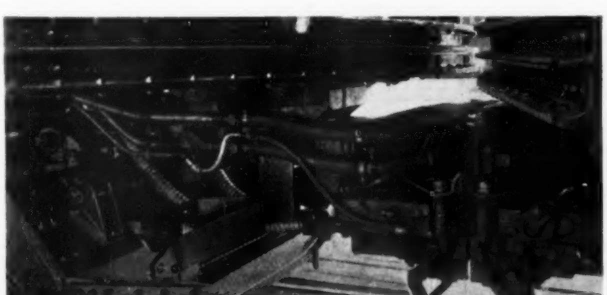


FIG. 4 AUTOMATIC COUPLERS FOR THE AIR AND ELECTRICAL CONNECTIONS

FIG. 5 TRUSS-PLATE FLOOR CONSTRUCTION—SALAMANDER INSULATION IN PLACE

short track length. These requirements make weight reduction imperative.

ALUMINUM USED EXTENSIVELY

The trucks are of the built-up pedestal type and the main carrying members are made of rolled bars, structural shapes, and a minimum amount of pressed plates, the pedestals being of cast steel. This type of construction resulted in a saving in weight of about 2000 lb per car. A considerable saving also resulted from the use of aluminum throughout the car body and equipment. Thus, the lower-deck headlining, doors, seat boxes, and the lower swing-sash panel are made of aluminum-alloy sheets. The door-engine equipment and much of the control equipment are also of aluminum, and a thin-walled steel conduit, ¹/₁₆ in. thick, with threadless fittings is used.

The floor construction also embodies weight-saving features that do not reduce strength, and consists of truss plate with a Tucolith plastic composition covering. With this latter material rounded sanitary corners which are kept clean easily can be readily formed. It is also fireproof and has a non-slip surface.

The car body completely equipped weighs 48,300 lb and the passenger load that may be carried is 39,200 lb so the car-body and equipment weight is approximately 55 per cent of the total load carried by the trucks. The complete car weighs 1405 lb per running foot when empty, and 2058 lb when fully loaded. The weight per seated passenger is 1405 lb, and per seated or standing passenger at full load, 301 lb.

NOISE REDUCTION A FEATURE

For deadening the noise of the new cars, Salamander insulation is placed on the inside of the steel side sheathing and on the under side of the roof. Inaccessible places have four coats of Voltax cork paint, which helps

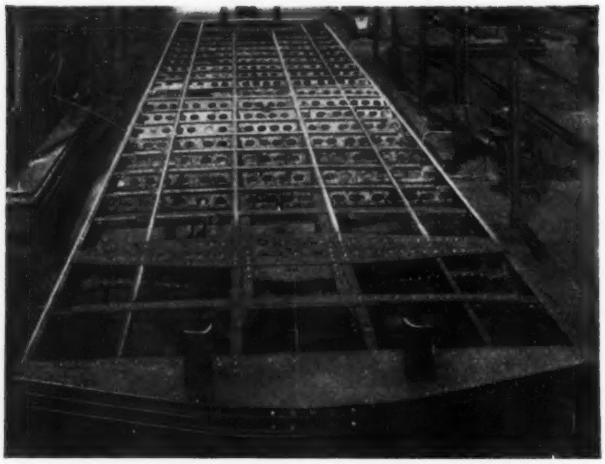


FIG. 6 ONE OF THE CAR UNDERFRAMES

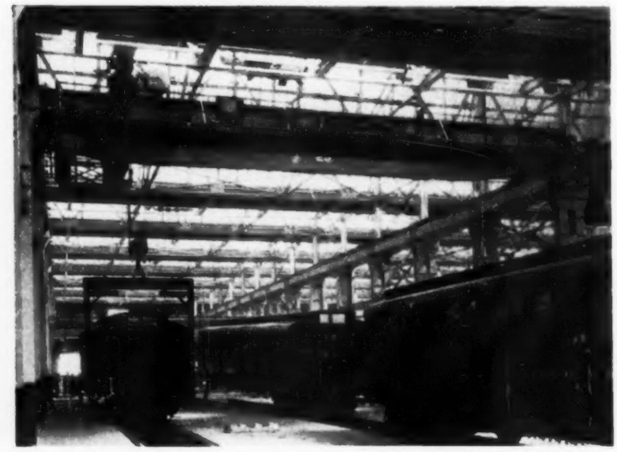


FIG. 7 LIFTING ONE OF THE NEW CAR BODIES IN THE REPAIR SHOP

considerably to deaden the drumming of the sheets. The wainscoting on the sides of the car is of Thermasote (Agasote faced with steel). The truss-plate floor construction covered with Tucolith has sound-deadening qualities, and, instead of resting on the center sills of the car, the floor rests on a strip of $^1/_2$-in. asbestos lumber. Noise vibration from the trucks is thus broken up and reduced. The trucks have fewer parts than usual, and the clasp brakes used on the wheels reduce chattering. The car being 10 ft wide, a greater area than usual is provided for intercepting track and truck noise and confining it underneath the car. The gears of the driving motors are of the long- and short-addendum type, and are very quiet in operation. To deaden the resonant sound, cast-iron rings are pressed into each side of the gear rims. Insulated gear cases are also being experimented with in an endeavor to confine gear noise.

At all wearing surfaces close tolerances have been used, and much high-manganese rolled steel is incorporated in the construction so as to keep wear to a minimum and thereby reduce the effect of blows resulting from impact of one part against another. Doors are closely fitted to prevent rattling, and their rubber buffers provide tight joints to keep out noise and cold. In the installation of apparatus particular care has been taken to make maintenance easy so that equipment can be kept in good condition and noise thereby reduced.

SOME FEATURES OF THE EQUIPMENT

Connections for the cars, air lines, and low-voltage-electric circuits are made by automatic car, air, and electric couplers. These latter provide an easy and quick method of coupling and uncoupling through the operation of a valve either in the motorman's cab or at the rail. Twenty-six train-line wires connect through the electric couplers and carry battery current for control of the motors, brakes, door engines, lamps, fans, heaters, and destination signs. The electric contacts are covered when cars are uncoupled.

The air brakes have 18 × 12-in. cylinders. Variable-load mechanism provides for a standard rate of retardation and acceleration irrespective of the number of passengers on the car. The cars have automatic slack adjusters on the brake cylinders, and the motor trucks have shim slack adjusters. Both motor and trailer trucks have Simplex clasp brakes and Diamond S brake-shoes.

Each car is driven by two Westinghouse No. 570-D-5, 190-hp field-control motors. Westinghouse ABF electropneumatic control makes it possible to run a train of from one to eleven cars from a single position. Control is of the automatic battery-field type, with acceleration set at the rate of 1.75 mph per sec. There also is a variable-load feature for the accelerating relays, so that the rate of acceleration is maintained regardless of load. The operating coils of the line switch are actuated by third-rail current, so that the main motor circuit is opened immediately on loss of power, but the multiple-unit control is operated from a low-voltage storage battery. This simplifies the design of the control apparatus, provides a means for easy testing of the control apparatus without the use of power from the line, and causes all the high-voltage circuits to be interrupted under the floor of the car.

Good lighting of the car interior is obtained from 22 Mazda C Type A-21 automatic-cut-out lamps in series, each lamp taking 1.6 amp at 30 volts and being set in a short-circuiting socket.

Four battery emergency lights per car go on when the power is off the line. Each car has an Edison 24-cell Type B-4-H battery, regulated automatically by a charging panel, which allows the battery to charge in series with the compressor motor; or, if this rate is not sufficient, directly from the third rail through a resistance.

The car lamps, heaters, ventilating fans, and destination signs have their circuits so arranged that they can be controlled from the motorman's position at the head of the train, for all eleven cars—the maximum number contemplated—or less. The destination signs on the ends of the train are adjusted by the motorman, and

once set for a particular line are not changed during the run. Side destination signs are set for the particular run, but the designation of the terminal toward which the train is proceeding is illuminated in color and is changed from one direction to the other by the setting of the motorman's reverser handle. Besides the end destination signs, which give the route number and destination in large illuminated characters, red and green illuminated signs on each side of the ends of the train show whether it is a local or an express.

The door control is arranged for multiple-unit operation, the front half of the train, up to a maximum of six cars, being controlled by the conductor, and the rear half, of five cars or less, by the guard.

MANY SAFETY FEATURES EMBODIED

A safety feature embodied in the door control consists in having the electropneumatic door locks controlled by a separate circuit from that of the door opening and closing mechanism. Two emergency door-operating switches are provided in each car to open one-half of the end side doors. These can be operated from both the inside and outside of the car. There are emergency handles at each door engine to open the side doors in the event of failure of air pressure.

As an added safety feature to reduce to a minimum the possibility of irregular circuits due to breakdown of electric insulation, a separate conduit is used for each individual wire.

Sliding doors are provided at each end of the car to permit passage through the train. The windows have brass sash glazed with plate glass, and the upper sash is arranged to drop for ventilation. The monitor-type roof has ventilating panels. The seats are both transverse and longitudinal, and are upholstered in rattan; and properly located white-enameled stanchions serve to support standing passengers who cannot reach the enameled hand straps.

NEW SHOPS AND CAR-STORAGE YARDS

A 45-acre plot is used for the maintenance shops and car-storage yards at 207th Street and Tenth Avenue. The shop buildings are completed, but at present are only partly equipped. It is planned to provide the necessary shop tools for maintaining 500 cars. Further additions will be made as needed. Tables 2 and 3 give floor areas of the shop facilities and the car capacities of the yards and shops.

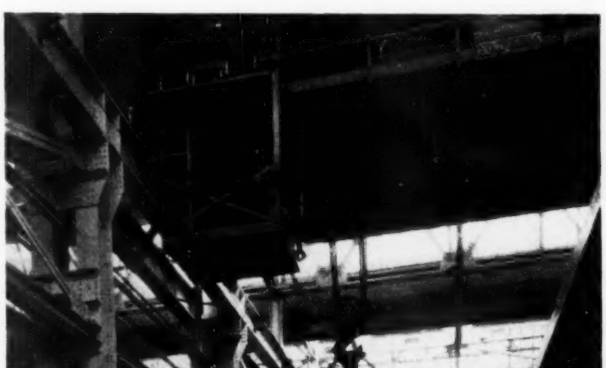


FIG. 8 HANDLING TRUCKS WITH OVERHEAD CRANES IN THE TRUCK REPAIR DEPARTMENT

The main group of buildings consists of a large central repair shop with connecting buildings on either side for the various shop departments. The car repair shop is 232 ft wide by 380 ft long. It has 12 tracks, each provided with a pit for the entire length. The width is divided into four bays, with 30-ton overhead cranes spanning each bay. There are five of these cranes at present, but provision is made for two in each bay when needed. The truck-overhauling shop is to the north of the car repair shop, and the wheel-and-axle department still farther north. Pits are provided in the tracks of the truck shop, and each track is spanned by a 5-ton overhead traveling crane. These cranes are provided with runways so that they operate underneath the 30-ton cranes. There is a cross passage, served by a 15-ton overhead traveling transfer crane, between the truck and car-body repair-shop sections.

The scheme for handling repairs is for cars to be placed in the repair section with sufficient space between the ends of adjacent cars so that the trucks can be handled by the cranes. The car bodies are lifted by the cranes and placed on steel horses, and the trucks are then taken by the cranes to the truck shop where they are dismantled. The average travel necessary for a truck in this operation is 290 ft. Motors and electrical parts go to the electrical repair shop on the west side of the truck shop, and metal parts needing repair to the blacksmith shop on the east side. The machine shop is at the west side of the car repair shop, and on the east side, in addition to the blacksmith shop, there is a wood mill, carpenter shop, paint shop, and car-inspection shop. The storehouse and office building is along the west side of the property. Material is handled between the storehouse and the various departments by electric trucks, and a telpher system serves the shops on either side of the car repair shop and goes across both ends of the truck shop. A 3-ton traveling crane is installed in the storehouse, and there are 5-ton cranes in the electrical machine shop, wheel and axle shop and blacksmith and carpenter shops. Jib cranes will be installed for serving machine tools, and

TABLE 2 FLOOR AREAS OF SHOP FACILITIES

	Sq ft
Main Group of Buildings:	
Car repair shop	102,400
Inspection shop	73,200
Truck shop	40,960
Carpenter shop and wood mill, including mezzanine	38,200
Paint shop	36,480
Wheel-and-axle shop	30,720
Machine shop, including mezzanine	30,400
Electrical repair shop, including mezzanine	24,000
Blacksmith shop and welding section	13,000
Total	389,360
Service Building:	
Material test department	7,360
Signal department	6,300
Truck department	4,820
Carpenter shop	4,730
Tinsmith and plumbing	2,100
Lighting department	768
Total	26,078
Maintenance Quarters:	
Truck section	448
Drainage section	340
Third-rail section	340
Lighting section	265
Total	1,393
Oil House:	
Oil, waste, and renovation	4,000
Paint storage	4,000
Total	8,000
Office and Stores:	
Locker, wash, and lunch rooms	26,480
Office space	32,000
Storehouse	31,000
Total	89,480
Miscellaneous Buildings:	
Substation	7,296
Boiler house	3,856
Battery house	1,200
Signal tower	1,104
Four transformer houses	325
Total	13,781

TABLE 3 CAR CAPACITIES OF YARDS AND SHOPS

	Number of cars	
	Initial construction	Ultimate construction
Storage yard	364	574
Inspection shop	54	66
Car repair shop	60	84
Paint shop	27	33
Total	505	757

also in parts of the shop not readily reached by the traveling cranes or telpher system. There is a mezzanine floor over the machine shop, electrical repair shop, carpenter shop, and part of the blacksmith shop. Four elevators are used to handle material to these floors.

PROGRESSIVE SYSTEM FOR REPAIRS

In the arrangement of the shops the departments are so located that work progresses from one operation to the next, with a minimum of handling, with no re-routing, and without interfering with other work. The most modern methods are to be used. Thus a dry kiln is provided in the wood mill, an electric-welding section near the blacksmith shop, a babbitting room in the machine shop, and a baking and impregnating room in the electrical repair shop. Compressed air will be used for cleaning operations, for jib-crane operation, and for other air tools, and both direct and alternating current will be provided for test purposes.

Other buildings included in this group are a track and signal service building, boiler house, oil house, battery house, a substation, line maintenance quarters, two signal towers, and four transformer houses. Provision is made in the layout for future construction of an administration building and garages.

The location is an ideal one for running cars into and out of the shops from the subway system. It is on the Harlem River, and a float bridge is arranged for landing cars and material from barges. Material delivered by truck enters the north end of the yard, and a storage shed open on two sides provides for easy unloading and handling. A 200,000-lb car scale and a 20,000-lb truck scale are provided, and one 1000-lb platform scale will be installed in the material shed. A coal and ash hopper at the northeast corner, right at the river, is equipped with a 3-ton electric locomotive crane so that coal can be unloaded from barges and ashes loaded for taking away.

The coal-handling plant provided at the 207th Street yard has a 2000-ton coal pocket, and about 300 tons additional storage is provided in the bunkers of the boiler house. The maximum daily consumption will be about 60 tons. At the boiler house there are a coal hopper into which carloads of coal are dumped, conveyors, a crusher, and an elevator. Trackage is provided so that coal may be hauled through the subway to other yards, if desired. Ashes are handled by a steam-jet ejector in the boiler house to an overhead bin and thence by a car to a sunken pit on the waterfront, from which the locomotive crane lifts them to an elevated bin from which they are spouted to barges.

The buildings are all of brick, with "high-low" roof construction, fitted with windows so as to give an abundance of daylight. Steel rolling doors are provided at the ends of the shops for cars. The shops are wired for both alternating and direct current. The shop lighting system using alternating current. The yard is flood lighted from four towers, and in addition incandescent lights are installed along roadways and walks. There is no third-rail construction inside the shops, but overhead rails are provided in the inspection shop to supply power for moving cars and for test purposes. Traveling trolleys running on overhead rails have a flexible cable connection for plugging into cars to move them inside the inspection shop. Motor flat cars are provided with reels of cable to connect with the outside third rail to move cars in and out of the repair shop and paint shop.

FLOOR CONSTRUCTION

Three types of floor construction are used, cement, wood blocks, and asphalt blocks. The shop areas where most of the repair work is done have wood-block floors,

the aisles between tracks in the inspection and car repair shop and outside passages are of cement, and the mezzanine floors, outside platforms, and chemical laboratory, of asphalt blocks.

The buildings are heated by a unit-heater system with fans and thermostatic control. Steam is supplied from the boiler house at 150 lb pressure and is reduced to 60 lb pressure at the shop unit heaters and to 5 lb at the office heaters.

There are three 607-hp boilers with automatic stokers, forced-draft fans, automatic combustion control, etc., with space for a fourth boiler. Steam is also furnished at high pressures for lye kettles and other industrial uses. In the buildings where there are large open spaces, unit heaters are mounted in the roof trusses 20 to 40 ft above the floor. These heaters contain pipe coils in which steam is condensed by blowing air at high velocity over them; the condensate is returned to the boilers by vacuum pumps. In addition there are pipe coils in the track pits and a few other places, and cast-iron radiation in small rooms. There is control of the heat both by time clock and by thermostats.

A sprinkler system is installed throughout the shops for fire protection. There are also convenient fire hydrants for hose attachment. The yard has fire-fighting towers, and is also a complete signal and fire-alarm system.

The layout of the tracks in the car-storage yard is most impressive, and the arrangement has been made particularly for convenience in getting trains into and out of service rapidly. Outside the buildings there are 40 tracks. These are connected to three ladder tracks that lead into the subway. These tracks are all provided with third contact rails of standard construction. The tracks are spaced 13-ft and 13-ft 6-in. between centers. As the width of the cars is 10 ft overall, there is 3 ft or more of side clearance between trains. Inspection work can thus be done in the yards if conditions should require it. At present the tracks do not run the entire length of the yard, but the layout provides for this to be done as soon as the total storage space is needed. With the ultimate construction provided for there is storage space for 574 cars outside the shops. Three tracks along the extreme easterly side of the yard and one track between the office building and the shops are intended for use in receiving and transporting supplies. The one between the buildings runs alongside the storage house and also serves the material shed. The other three tracks referred to are along the Harlem River and connect to the float bridge so as to handle all cars that come into the yard on floats. Two loop tracks run across the northerly end of the yard and serve as ladder tracks.

Courtesy of the Okonite Co.

FIG. 9 AIRPLANE VIEW OF THE NEW 207TH STREET SHOPS

MECHANICAL ENGINEERING

Vol. 54 JANUARY, 1932 No. 1

GEORGE A. STETSON, *Editor*

Vocational Training for the Unemployed

IN ITS Bulletin No. 159, "Vocational Training and Unemployment," the Federal Board of Vocational Education discusses a question of immediate interest and vital concern to practically every community of the country: "What service can the public program of vocational education render to the unemployed?" The bulletin is divided into three parts. The first outlines the problem of the worker displaced by technological changes in agriculture and industry. The second describes the national program of vocational education as organized under the Smith-Hughes Act of 1917, and indicates some ways by which it may be extended in the light of the present emergency. The third section contains suggestions relative to steps which may be taken by a local community in the organization and operation of special training programs to meet the needs of unemployed groups.

The unemployed workers whose problem is discussed in the bulletin referred to are principally of the nonprofessional manual and "white-collar" classes. In so far as engineers are interested in the civic and economic life of the communities in which they live and may be responsible either for some of the causes of technological unemployment or for aiding in the solution of a pressing local problem, the suggestions contained in the bulletin will be of interest to them. Frequently in these pages we have called attention to the desirability of considering the social and economic consequences of the technological changes which may, at times, be introduced without a proper study of the worker's problem. We do not wish to be understood as proposing a cessation or even a slowing up of technological developments. We suspect, however, that not enough thought has been given to the introduction of such changes and improvements in a socially desirable manner. Undoubtedly if those who are engaged in trying to adjust the displaced worker to changed conditions—for example, those who are conducting vocational training schools—could receive greater cooperation from those who "hire and fire" him, the problem would be less acute. If, for example, provision for the workers likely to be displaced was considered in every case, at the time the new machine or process was contemplated, the social problem would become more generally an integral portion of the technological one. While it is true that a considerable percentage of technological changes are made because a reduction in labor cost is possible, and while a plant employing 200 men is a greater social asset than one which runs itself into insolvency and extinction trying to keep 250 employed, these factors do not justify the elimination of the worker's welfare from consideration. If the displacement of workers is a part of an industrial program, an early knowledge of it by those concerned would seem wise, and, in case distress is likely to result, the benefits of vocational readjustment by properly organized groups should not be overlooked.

We have already called attention to the benefits that unemployed engineers may derive from further schooling. We are glad to report that many universities are meeting the situation with exceptional terms.

Science and the Community

IN A PUBLIC lecture delivered at Cornell University under the George Fisher Baker Foundation, and printed in the November 20 issue of *Science*, Prof. Cecil H. Desch, of the University of Sheffield, talking on "Pure and Applied Science," directs attention to some of the social aspects of science. Readers who have pondered the distinctions implied in the title of Professor Desch's lecture and who are interested in the relation of science to culture and civilization, will wish to read all of what he had to say.

Professor Desch comments on the Marxian philosophy of science and research interpreted by the Soviet delegates to the International Congress on the History of Science held in London last summer. This philosophy emphasizes the utilitarian value of science and research to the community, and virtually denies the importance of genius and the ultimate value of research dictated purely by scientific curiosity. Recognizing the shortcomings of such a theory, Professor Desch shows that some of our most practical and important inventions were possible only because they made use of apparently useless scientific facts unearthed by men with no interest in their practical value to society.

Because of the many contributions that have been made to applied science and industry by independent workers, the history of science becomes of great importance to those training in particular fields and offers a means of bridging the present-day gulf between scientific and humanistic studies. "The development of scientific thought," says Professor Desch, "is such an essential part of the history of civilization that it should be prominent in the teaching of general history." Alas, it is not.

As civilization progresses, science becomes a more important factor in determining its development and in the lives and culture of civilized peoples. Hence it can no longer be considered apart from the community, as "every worker in such a field must have some consciousness of its social significance."

Science is neither good nor evil except as men make it so. Human nature has changed but little, if at all,

since the dawn of recorded history. Evolution in man's mental ability is discouragingly slow. Science has remade the environment in which man finds himself, and has removed the natural barriers to transportation and communication that formerly existed. The predatory, self-defensive, and egocentric instincts of man make disastrous use of the discoveries of science. Until such time as man can develop a science of society as extensively and as expertly as he is developing natural science and coordinate the two with intelligence and profit, the advance of natural science will continue to bring abuses with it. Hope for the future lies in such development and coordination.

Sick Industries

The bituminous-coal industry is very badly off both in this country and in England, and its ills formed the subject of an animated discussion at the Third International Conference on Bituminous Coal held in Pittsburgh last November.

The most significant utterances came from Myron C. Taylor, Assistant Chairman of the Board of Directors of the U. S. Steel Corporation, who told the conference that in the first place it was up to the industry itself to find its salvation, and asserted next that if the industry in the course of breaking out of the present slough of despond should have to organize on a national scale, it would be very unlikely that any step sincerely undertaken to solve the present problems and not intended for the control of prices on coal in the slightest interest of the producers, would be subject to prosecution by the United States under the anti-trust laws.

Many plans were offered for the control of the industry, some involving agreements between producers, others action by states, etc., but those that attracted the most attention were what might be called old-fashioned remedies and not magic schemes for showering the industry with prosperity overnight. Bituminous coal, notwithstanding the development of hydro power and oil and gas, still remains the greatest source of energy generation in the United States, and because of its magnitude the weal of the industry is of importance to every citizen of the country, and particularly to every mechanical engineer.

The oil industry has been in trouble practically since the war. Fifteen years ago all the talk was of the threat of dollar-a-gallon gasoline to the automotive industry. Today the problem is how to get a price that will pay the costs of production for the enormous flow of oil from the ground. Prorating by states has been attempted, but it took the National Guards of the states of Oklahoma and Texas to force a price for crude oil that would make it possible to keep the producers going.

The worst is that there is every reason to believe that the situation not only is not improving but, unless something real is done to relieve it, may become much worse.

Among other factors, the development of geophysical methods of exploration may play the part of Pandora's box by informing the world where all of the big deposits of oil are located before the world has become wise enough to have such knowledge without hurt to itself.

The copper industry has just been analyzing its troubles on an international scale. There was a time when American copper dictated the world price for that metal. Then came the discovery of the huge copper deposits in Chile; but the world situation has been entirely revolutionized within the last few years by the development as producing units of copper deposits in the Belgian Congo known as the Katanga Group, and in Rhodesia as represented by the Roan Antelope.

Soon after the stock-market crash of 1929 the copper producers agreed on a price of 11 cents a pound. This rapidly dropped to 10 cents, and even below that, which was only natural if it is true that with its recent acquired railroad facilities the Katanga mines can sell copper at a profit for 6 1/2 cents a pound. Incidentally, it is these same Katanga mines whose low prices of radium forced the virtual closing of the Colorado properties in this country. The discussions of the representatives of the world's copper interests in the last two months, and particularly those in New York City, have been full of the drama and tragedy of international finance. Even after all the others had agreed on a drastic curtailment of production, the representatives of the Belgian interests held out for a preferred position. It was only after a number of representatives of the Mining Union of Upper Katanga, as the Belgian company is officially known, had sailed home that a turn in the negotiations took place. This was brought about, it has been stated, by the withdrawal of the Phelps Dodge Company, one of the largest producers of copper in the United States, from the Copper Exporters, Inc., an association for the control of copper exports by American producers. It was easy to see in this action of the Belgian representatives a portent of price cutting without stint, and the withdrawal of Phelps Dodge was particularly impressive since, unlike some of the other large American interests, they are not heavily interested in the African copper properties. All indications are, therefore, that a world-wide agreement will soon be reached on a curtailment of copper production of something like 50 per cent. This agreement is to differ somewhat in principle from the Chadbourne-Gutierrez international sugar agreement, which may be just as well as the latter is not working out quite to the satisfaction of all concerned, judging from the agitation against its operation in Cuba, the country of its origin.

Agriculture, copper, oil, bituminous coal, and sugar are the largest of the sick industries, and the brightest minds all over the world are working hard to restore their health. It behooves all of us to watch what is being done for them, because the lessons thus learned may be useful in dealing with the numerous small, sick industries which are not spectacular enough to attract universal attention, but which are acutely suffering nevertheless, and are causing thereby widespread general distress.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

Safety in Spinning

A PAPER under this title was presented in the early part of November before the Royal Aeronautical Society in London by H. B. Irving and A. V. Stephens, and brought out very clearly the value of model experiments in revealing structural features of importance in spinning. They have replaced free-flight trials of balsa-wood models launched into still air by free-flight tests in a vertical glass-walled wind tunnel in which the descent of the spinning models is neutralized by the upward speed of the air stream.

The striking feature of the spinning problem in its present stage of partial elucidation is undoubtedly its complexity. In one or two directions, however, conclusions of a fairly unqualified nature are beginning to emerge. The most definite of these take the form of the general principle that in any consideration of factors conducive or otherwise to safety in spinning, aerodynamic and inertia characteristics must always be regarded in relation to one another. These aerodynamic properties which prove favorable in one machine may be found detrimental in another where the mass distribution is different. The principle of the relative importance of inertia and aerodynamic quantities throws light on many puzzling features of spinning aircraft.

Instances of suddenly facilitated recovery after spins of long duration may be explained on the ground that with increasing air density due to loss of height, aerodynamic forces and couples are increased sufficiently to assume control over the engaged inertias. Similarly the not uncommon occurrence of a dangerous spin being arrested when the pilot is on the point of taking to his parachute, may be ascribed to a favorable change of inertia due to the new position of the pilot's mass.

One general inference from the results of recent experimental work is that the most effective control for producing recovery from an established spin is the rudder, the actual corrective being the yawing moment against the direction of spin. It would appear that while appreciable departures from conventional design may be demanded by aerodynamic considerations, better aircraft can be regarded as unspinnable. (Abstract from an editorial in *Engineering*, vol. 132, no. 3435, Nov. 13, 1931, pp. 614–615, *etA*)

Light Alloys in Aircraft

THE present paper deals with the principles of the engineering choice of materials for aircraft construction rather than with the specific alloys. There is no choice between metallic and non-metallic materials in aircraft engines as they have to be made of metal. In the remainder of the ship there is also a preponderance of metal. In lighter-than-air craft the framework and girders are always of metal, and in one type the skin is also of metal. Where in airplanes wood was used it is gradually being superseded by metal. Where stiffness is necessary the bulkier light alloys, with the correspondingly better section modulus, are more usable than the heavier and stronger ones with which it is necessary to go to very thin sheet and tubing to compete on a strength-weight basis. As the ships get larger the advantage of the bulk material grows less.

Fabricability—the ease with which the material can be shaped, and particularly its suitability for welding—comes in very strongly, as fabrication cost is a very potent factor in the choice of materials. On the other hand, the cost of the material itself comes last on the list of factors for choice. Furthermore, 100 per cent dependability is required, and a uniform material of medium properties is preferable to one of higher average properties but prone to give a faulty performance now and then.

Many of our usual engineering structural alloys are barred at once on cursory examination of their strength-weight ratios. Brass, monel metal, and ordinary steel are, save in very minor cases, entirely out of the running; they are too heavy. Useful alloys are either very light or very strong.

If the steels are heat-treated or cold-worked to around 150,000 lb per sq in. their static yield-strength-weight ratio is just about the same as that of duralumin or of the stronger magnesium alloys. It is easy to heat-treat alloy steel to give 200,000 lb per sq in., in which case the steels are far superior on the strength-weight basis. Nevertheless, it is only in landing gear where very high stresses are encountered and where the members are necessarily fairly large, that general practice utilizes the highly treated steels. In smaller parts, such as wing spars, the section modulus makes the bulkier duralumin a more common choice.

There is still competition as to materials for the stress-carrying framework, and the last word has not been said. Magnesium alloys are avoided because of their tendency to corrode, but with designs giving good accessibility for inspection so that incipient corrosion can be caught, the magnesium alloys might have a better chance to compete.

The ratio of endurance under repeated stress to weight is a paramount factor in the choice of material for a propeller. In large propellers, magnesium alloys with their low specific gravity would be superior, from the endurance point of view, to the heat-treated aluminum alloy now standard, and some have given very satisfactory performance. Their use is delayed by the fact that they are more difficult to fabricate.

A hollow steel propeller would be far superior on the endurance basis to one made from any of the light alloys, besides having a better modulus of elasticity and hence better uniformity of pitch at various loads, but the manufacture of a properly balanced hollow steel propeller without the use of welding, which one hesitates to trust in such service, is a difficult job. The difficulties with both the magnesium and the hollow steel types appear to be on the road to being overcome. Nitriding the surface of a hollow alloy-steel propeller has been suggested, and would probably add a good deal to endurance as well as to wear resistance, which latter is also a factor. The steel propeller will be more difficult, and a nitrided one impossible, to repair after it is bent in a nose-over, while an aluminum-alloy propeller can be repaired, and the light propellers should hold

their place for some uses, but the present supremacy of the aluminum alloy is likely to be more and more disputed.

Aircraft makers as a class are as yet design minded rather than material minded. The time must come when the aircraft people themselves will go into research aimed at the development of better materials for their use. For example, no one knows whether a new class of light alloys with beryllium as a base, and which might be superior for aircraft use, can or cannot be produced, but since there is a chance of it, should not the aircraft makers themselves be working with beryllium instead of waiting for some one else to work out all the details and bring them a perfected alloy, ready for use? If continued improvements are to be made, the user of these special materials ought to take his fair share in the development. (Paper by H. W. Gillett, Battelle Memorial Institute, before the *Metals and Alloys Conference* at Case School of Applied Science, Nov. 18–20, Cleveland, Ohio, abstracted from mimeographed preprint, *g*)

ENGINEERING MATERIALS (See also Aeronautics: Light Alloys in Aircraft)

Aluminum Solder

A SOLDER that will repair aluminum and other metals, including pot metal, die castings, cast iron, and steel, has recently been discovered by the Allied Research Laboratories of Glendale, Calif. It is called Alumaweld and has a tensile strength of 12,000 lb, which is more than ten times that of ordinary solder. It is very ductile, and will take a nice polish over which chromium plating or any other plating can be applied. It is hard enough to be worked or machined, yet exceedingly malleable.

Alumaweld has a primary melting point of 370 deg. Once melted, however, there is a secondary melting point of from 50 to 250 deg higher, depending upon the period of time that the solder has been allowed to remain in a molten condition. This feature naturally makes for permanence of repairs.

Alumaweld is applied to aluminum, pot metal, and die castings with an ordinary soldering iron or blow torch, without flux. For cast iron and steel a special flux is required. Alumaweld is one of the few metallic materials that will not corrode under ordinary circumstances, and there is absolutely no possibility of its rusting, because of its neutrality, combined with the fact that it fuses with the metals to which it is applied. Electrolysis is consequently eliminated. (Abstract from a press release issued by the Allied Research Laboratories.)

Cement-Water Ratio for Concrete Mixes

THE relation between the water-cement ratio and the strength of concrete is usually given by a logarithmic equation. If, however, the cement-water ratio is used instead of the water-cement ratio, the strength-ratio curve becomes nearly a straight line. Plotting the Abrams and Talbot-Richart curves to the cement-water ratio by weight basis gave nearly a straight line of opposite inclination to the more usual water-cement-ratio curves. The author expresses the strength of concrete by the formula

$$S = A + B(c/w) = A + Kc$$

where S is the strength of concrete, A and B are constants depending upon the materials and conditions of tests, c/w is the cement-water ratio by weight, K is a constant, and c is the cement content per unit of concrete.

An important significance of the relationship shown is the recognition of the fact that the cement is the strength-giving element in concrete.

A prominent saving in using the cement-water relationship is made possible by the straight-line relation, because two well-established points will determine the entire strength-cement-water-ratio relation, while four or five points are needed to establish the curved strength-water-cement-ratio relation. Where the type and grading of the aggregates are such that a given amount of water per unit of concrete gives practically constant consistency, regardless of mix, a further saving is made possible by the fact that the one trial mix will determine the approximate consistency of all mixes, while otherwise one trial mix is necessary for each richness of concrete. (Inge Lyse, Research Assistant Professor of Engineering Materials, Lehigh University, Bethlehem, Pa., in *Engineering News-Record*, vol. 107, no. 19, Nov. 5, 1931, pp. 723–724, 2 figs., *p*)

Endurance Properties of Some Well-Known Steels in Steam

THE endurance properties of nickel steel, a non-corrodible chrome-iron alloy, several nitriding steels, and an austenitic steel of the 18 per cent chromium, 8 per cent nickel type, have been determined in air and in steam under various conditions of temperature and pressure. The following conclusions are cited:

The endurance properties of high-strength nickel steel and non-corrodible chrome-iron alloy in the absence of appreciable quantities of liquid water and oxygen were not adversely affected by steam atmospheres up to and including pressures of 220 lb and temperatures of 700 F.

Due to the presence of liquid water and oxygen, the steam-jet–atmosphere endurance values of the above steels were but 41 and 54 per cent of the corresponding air–room-temperature values. As evidenced by the steam-jet–atmosphere tests of nickel steels, if the corrosion be severe, the endurance values are not a function of the initial tensile properties of the material. A comparison of the steam jet in atmosphere and precorroded air–room-temperature values of the high-strength nickel steel further emphasizes the damaging effect of the simultaneous presence of stress and corrosion. On the other hand, no damaging effect of the precorrosion treatment on the non-corrodible chrome-iron alloy was evidenced by any of the tests carried out thereon.

The ratio of air–room-temperature endurance limit to ultimate strength was higher in the case of the nitrided nitriding steels than in that of any of the others tested.

A marked tendency of the endurance values of the nitriding steels to drop off with increasing temperature was observed.

The ratio of the steam-jet–atmosphere to air–room-temperature endurance values was higher in the case of the nitrided nitriding steels than in that of the other steels tested.

The 60-lb 149-C (300 F) steam endurance value of notched nitrided specimens ranged from 74 to 83 per cent of that shown by corresponding unnotched specimens.

The endurance properties of the 18 per cent chromium, 8 per cent nickel type of alloy are seriously affected by long intervals of time at temperatures of 650 C (1200 F) and above.

In the hot-rolled condition the endurance values of this alloy bear a relationship to carbon content. This relation, however, is found to disappear after drastic treatment at elevated temperatures.

A chromium plate offered considerable protection to the high-strength nickel steel against the corrosion of the steam-jet–atmosphere test. (T. S. Fuller, Research Laboratories, General Electric Co., Schenectady, N. Y., in a paper before the

Annual convention of the *American Society for Steel Treating*, Sept., 1931, abstracted from preprint, 15 pp., 13 figs., *e*)

Fusible Alloys in Metal Forming

FUSIBLE alloys have been used to some extent in metal-forming operations, but the potential possibilities of these alloys are not generally appreciated.

All of the very low-melting alloys contain bismuth in large quantities, and this high bismuth content imparts non-shrinking properties to the alloys. The ternary bismuth-tin-lead eutectic contains approximately 52 per cent bismuth, 32 per cent lead, and 16 per cent tin, and melts at 96 C (205 F). The melting points of ternary alloys can be varied over a considerable range by changing the proportion of the different metals. The melting point of the eutectic of quaternary alloys of bismuth, lead, tin, and cadmium (Wood's or Lipowitz' metals) has a melting point of 70 C (158 F). A typical Wood's metal contains 50 per cent bismuth, 26.7 per cent lead, 13.3 per cent tin, and 10 per cent cadmium. Lately one of the large electric manufacturing companies developed particularly for mounting dies and punches, an alloy known as "matrix" alloy. This is a quaternary alloy composed of 48 per cent bismuth, 28.5 per cent lead, 14.5 per cent tin, and 9 per cent antimony. The physical properties of some type metals, solders, hard leads and fusible alloys are given in Table 1.

TABLE 1 PHYSICAL PROPERTIES OF SOME TYPE METALS, SOLDERS, HARD LEADS, WOOD'S METAL, AND MATRIX ALLOY

Alloy	Percentage composition Bi	Pb	Sn	Cd	Sb	Tensile strength, lb per sq in.	Brinell hardness	Per cent elongation	Freezing temp., F
Hard lead	..	90.0	..	..	10.0	8,220	17	17.0	486
Hard lead	..	85.0	..	..	15.0	9,000	17	11.7	476
Linotype	..	84.0	4.4	..	11.5	11,700	21	9.0	476
Stereotype	..	80.2	6.5	..	13.0	12,000	22	4.0	468
Solder	..	60.0	40.0	..	..	6,890	11.8	117.0	464
Solder	..	50.0	50.0	..	..	6,400	11.1	96.0	421
Matrix	48.0	28.5	14.5	..	9.0	13,000	19.0	1.0	248
Wood's	50.0	26.7	13.3	10.0	..	5,990	9.2	140.0	158

Wood's metal is used as a pattern alloy, as a filler in forming and bending thin-walled tubing, and as a gas-tight seal between glass and metal. This use is possible because Wood's metal wets glass. In tube bending the alloy has the advantage that it does not stick to the tubing unless fluxes are used. Wood's metal can be used repeatedly provided it is not overheated.

The matrix alloy is hard and strong, and has very little elongation but a fairly low melting point. A figure in the original article shows a typical matrix-alloy mounting of a punch for stamping motor laminations. This particular die is made up of 32 separate punches, each held by a single locating screw in the bottom and then locked into position by pouring the matrix alloy around the punches. A broken punch can be readily replaced by melting out the matrix alloy surrounding the broken part, substituting a new punch, and pouring a patch of matrix alloy.

Matrix alloy is an ideal metal for the production of models and templets for the Keller die-sinking machines as it can be cast in green plaster-of-paris molds, does not shrink, and is hard and strong. These same properties make matrix alloy a very superior metal for the production of dental models, particularly for partial plate and bridge fabrication.

An interesting use of the fusible alloys, while not related to the metal-forming industry, is in the measurement of the temperatures in very deep oil wells. A series of cones cast of different alloys having known melting points of suitable range are mounted in a container and lowered in the well. The temperature in the well is indicated by the melting point of the highest melting cone found to have been melted, when the container is pulled from the well. High-mercury alloys melting as low as 58.6 C (137.5 F) are used at the lower ends of these series. These high-mercury alloys have very low tensile strength but are strong enough for this purpose. (Walter C. Smith, Metallurgist, Cerro de Pasco Corp., in *Metals and Alloys*, vol. 2, no. 4, Oct., 1931, pp. 236–237, 2 figs., *d*)

Use of Metals at High Temperature

AS REGARDS pearlitic steels, it has not been definitely proved that the addition of chromium, tungsten, molybdenum, and vanadium to ordinary mild steels improves greatly their strength at elevated temperatures. Low-alloy steels containing these elements should make excellent materials for steam plants, etc., where corrosive conditions are not severe, and the author refers to certain specific materials, including nitrided steel.

The maximum temperature recommended for 12 per cent chrome steel is 1100 F. All steels belonging to this pearlitic group should always be used in quenched or drawn condition, and it is essential that the drawing temperature should always be higher than the temperature at which the material has to operate.

The author next discusses the austenitic steels of various contents. Here precipitation of the carbide may alter the physical properties of the metal, and under certain conditions may lead to intercrystalline corrosion. Experiments have shown that precipitation will occur between 850 and 1800 F, which limits the range of use of these alloys. The conditions of use of metals at high temperature in internal-combustion engines, particularly in exhaust valves, are next discussed, as well as metals at elevated temperature under ordinary conditions.

For parts which are not subjected to severe stress but must have a long life under temperature conditions only, a large number of alloys has been developed. The cheapest material is cast iron, but its use is limited by its tendency to grow. The A.S.M.E. Boiler Code specification puts this limit at 450 F, but it is frequently used up to 700 to 800 F in other fields, and this is about its top limit. On the other hand, malleable iron can be used up to its critical point or below 1300 F. Some special high-silicon, low-carbon cast irons have been developed abroad. These irons are said to resist growth and oxidation up to 1650 F. (H. A. DeFries in a paper before the *Metals and Alloys Conference* at Case School of Applied Science, Cleveland, Ohio, Nov. 18–20, 1931; abstracted from mimeographed preprint, *dp*)

FUELS AND FIRING

Self-Electrification of Coal Dust

BY SELF-ELECTRIFICATION is meant the ability of coal to collect static charges. The following is an abstract of the report of an investigation carried out at the Buxton Research Station under the auspices of the British Mines Research Board. The interest of these tests lies in the fact that a large-scale plant was used, and, unlike previous tests, no foreign dust was mixed with the coal dust except when it was desired

to ascertain the specific effect produced by the addition of stone or other dust.

It was found that atmospheric conditions had an important effect on the development of spontaneous electrification of coal dust. When the humidity of the atmosphere rose above 65 per cent no charge could be obtained, even with the air at maximum speed and heavily laden with coal dust. There was no transition—either the apparatus indicated intense electrification, or none at all. This pronounced effect of hygrometric conditions suggested that although voltages of dangerous magnitude might be developed under laboratory conditions, under those of actual mining they might not be so readily attained.

Experiments made to indicate the effect of varying the rate of feed of dust with constant air-current speed, produced with the initial rate of feed 4000 volts; on doubling the rate of feed, 5800 volts were developed, and on quadrupling, 7000 volts. In each case the voltage was maintained as long as the passage of dust continued. Experiments made with standard "stone" dust gave similar results with copious sparking across gaps up to $^1/_8$ in.

The results of the tests were such as to indicate that even the simplest form of grounding, such as mere contact with the earth at a number of points or a single deliberate earth connection, is sufficient to prevent the accumulation of any charge in pipes or metallic ducts in which dust-laden currents of air are conveyed. (S. C. Blacktin and H. Robinson in Safety of Mines Research Board paper no. 71; abstracted through *Engineering*, vol. 132, no. 3434, Nov. 6, 1931, pp. 581–582, *e*)

Transportation of Pulverized Coal in Pipe Lines and Cars

ONLY the part of this report dealing with transportation in pipe lines is here given. Transportation of pulverized coal for great distances in pipe lines is done exclusively by pneumatic methods in Germany. Before the introduction of pulverized-coal firing in Germany, this method of transportation had been applied to bulk materials, grain, ashes, and the like. Pneumatic conveying can be done either by suction or by compressed air.

In general, suction operation is preferable, but it can only be used for distances up to 400 meters (450 yd). Pressure must be used for greater distances, but this can only be used up to 1800 meters (2000 yd). For still greater distances, intermediate stations must be installed. In many cases suction and pressure operation are combined.

Large pipe cross-sections must be used, as a large amount of air is necessary for transportation. The air consumption is between 120 and 300 cu m per metric ton of pulverized coal (4200 to 10,000 cu ft of air per long ton, or 1.5 to 6 per cent of the air required for combustion), depending on the length of pipe.

The intimate mixture of air and dust naturally increases the danger of explosion in the transporting installation, especially with high-volatile and easily ignited fuels such as brown coal. Consequently transporting installations for brown coal use an inert gas such as flue gas. In this case a circulating system is adopted so that the gas is used over and over again. Because of the danger of explosion when using air for transporting easily ignited dust, the pipe lines should not be placed in the vicinity of open flames or objects that radiate heat strongly, such as furnaces, ovens, or boilers. They must also be grounded, and electric wires should not be hung from them.

The return pipe circuit mentioned above has the advantage that the coal or air can be heated in order to prevent the moisture in the coal and air from condensing on the inside walls of the pipe lines. It is recognized that condensation of water in pipe lines causes adherence of the dust, and therefore rapid clogging and considerable trouble. In addition, the power consumption is higher with moist dust than with dry dust. In a plant built for a capacity of 9 to 14 metric tons (10 to 15 short tons) of pulverized coal per hour a moisture content of 5 per cent in the dust reduced the actual conveying capacity to only 4.5 to 5.5 metric tons per hr (5 to 6 short tons per hr). If moist dust is used frequently, a parallel line should be provided so that the main line can be blown out periodically in order to prevent clogging. If a return line is used, the dust that is not used can be returned to the bunker.

In addition to the requirements for minimum moisture content, a certain fineness of the dust must be observed. Ordinarily a dust with a residue of 1 per cent on a sieve with 76 meshes to the inch is required.

It is very important that the lines be straight, with as few bends as possible, and that the gradient be as uniform as possible without abrupt transitions. In rebuilding one installation the number of bends was reduced from 14 to 3, resulting in a power saving of 30 per cent.

With the high velocities of 20 to 40 m per sec (65 to 130 ft per sec) generally used, there is considerable wear in the pipe lines. In one plant that operated 24 hr a day, the bends had to be renewed after two years. Consequently it is advisable to make the bends with rather large radii so that the power consumption and wear will not be too great. In addition, they should be made so that they can be replaced easily or with removable sections. Frequently the outside of the bend is provided with a cement back. It also has been attempted to line the bends with basalt cement in order to reduce wear. The pipe beyond the bends is also greatly worn because of the eddies caused by the bends. The construction of the pipe must be considered carefully. A good design is that in which each pipe is inserted into the next, in the direction of transportation. In straight lines the wear is generally uniform throughout the entire pipe, as there is straight flow and eddies are formed only for short distances after the bend. A slight variation from a straight line causes a disturbance in flow which results in greater friction on the walls and increased wear. Constant vibration also can cause a disturbance of normal flow. This is very difficult to overcome in industrial plants.

In an installation operating under normal conveying conditions, using a pipe diameter of 110 mm (8 in.) and an air velocity in the pipe line of 20 m per sec (65 ft per sec) it was necessary to make a replacement after conveying 120,000 metric tons (130,000 short tons).

Leaks can be located easily, and naturally they must be repaired immediately. In suction operation one hears plainly the sucking of leakage air, and in pressure operation the dust is blown from the line. Both represent losses that must be reduced to a minimum by regular inspection. It is easiest to weld a strip of iron on the damaged places. The dead angles that are formed here and at the joints are soon filled with dust, so that dust rubs on dust and wear stops completely.

It is best to place the pipes overhead on supports, so that thorough inspection and easy repairing are possible. The pipes should not be placed in the ground. This makes inspection and repairing difficult, and the damage due to water is considerable. Water will easily enter at any leaks, and will affect transportation and may stop it altogether. It has frequently been objected that there is danger of freezing with exposed lines, but no cases of this are known. When the repair of a line costs too much it must be replaced.

The installation cost for a pulverized-coal conveying system with a capacity of 14 metric tons per hr (15 short tons per hr) and a length of 250 meters (270 yd) including blower but with-

out motor, is about 1400 to 1800 marks per ton ($340 to $430 per ton). (Friedrich Schulte, Director of the Association of Supervisors of the Power Industry of the Ruhr District, Essen, Germany, in a paper before the Third International Conference on Bituminous Coal, Pittsburgh, Pa., Nov. 16, 1931, *d*)

INTERNAL-COMBUSTION ENGINES

Hydraulics of Fuel-Injection Pumps for Compression-Ignition Engines

THE use of direct injection from the fuel pump for automotive compression-ignition engines has steadily gained in favor, particularly in Germany, and at present the use of a common-rail injection system with mechanically operated injection valve is rare for engine speeds of over 1000 rpm. The different types of fuel pumps used may be in general divided into two classes: pumps in which the fuel quantity delivered is controlled by the stroke of the pump, and pumps in which it is controlled by valves which bypass the fuel for a certain part of the stroke.

Two other types of pumps may be mentioned, namely, those in which the fuel quantity delivered is controlled by a valve which bypasses part of the fuel during the injection stroke, and those in which the fuel quantity delivered is controlled by limiting the fuel drawn into the pump on the suction stroke. It is stated that the construction of fuel-injection pumps has been perfected to a high degree, but that too little attention has been given to the hydraulics of the system. It is this that the present investigation is intended to correct.

The investigation is of a mathematical character and not suitable for abstracting. It deals with the following subjects.

First is presented an analysis considering compressibility but neglecting pressure waves. It is stated that the effect of engine speed on the instantaneous pressures presents one of the most serious difficulties in fuel-pump operation.

With fuel-pump injection systems the rate of penetration or the atomization of the fuel spray varies with engine speed. As a result it cannot be expected that the combustion characteristics will be the same at all speeds. This variation can be compensated for to a certain extent by the use of a variable-rate-of-lift cam in the fuel pump, and by so designing the pump that the low-rate-of-lift portion is used for high speeds and the high-rate-of-lift portion for the low speeds in which the rate of lift is considered with respect to pump degrees. This is followed by an analysis considering pressure waves. In general, there is a series of reflecting waves in the injection system caused by the partial reflection or, in some cases, the complete reflection of each successive wave at the discharge orifice. The form of all the waves is the same, and they differ only in amplitude. The phenomena consist, therefore, of two series of waves, one traversing the system from the injection pump to the discharge orifice, and the other traversing the system from the discharge orifice to the pump. The series do not interfere with each other, consequently the total pressure at any point in the injection system is the algebraic sum of the instantaneous pressures at that point.

The analysis is very interesting, but cannot be abstracted because of lack of space. Determination of velocity of pressure waves has been made directly as well as mathematically, and it has been found, among other things, that, other conditions remaining the same, the resistance to flow through the injection tube when the flow is turbulent varies inversely as the fifth power of the injection-tube diameter.

The analysis, however, holds only for certain sizes of injection-tube diameters. The second part of the report deals with an experimental determination of discharge pressures and the factors which affect them, particularly dimensions of injection tube, pump speed, and effect of the check valve. The application of the theory to pump design comes next, together with certain sample calculations and a brief review of the work of other investigators. (A. M. Rothrock in *Langley Memorial Aeronautical Laboratory Report No. 396, National Advisory Committee for Aeronautics*, 47 pp., 42 figs., *etA*)

MACHINE SHOP

The Rockford Hydraulically Operated Shaper

THIS shaper, with a hydraulic table drive and hydraulic feeds, is claimed to be the first hydraulically operated shaper on the market. In it the cutting speed is uniform and the cutting pressure constant from the beginning of the cut to its end. The reversal of the ram is smooth and free of shock. The limitations which handicap the rocker-arm type of drive in mechanically driven shapers are absent as a wide ratio of return to cutting speed can be used. The power is applied close up under the ram in a straight line directly back of the tool, and the moving parts of the ram drive are said to weigh only a fraction of those of the mechanical-drive shaper. The range of feed is unlimited up to the maximum of 0.160 in. The part for selecting the feed resembles a micrometer thimble, and its adjustment is similar. The feed movement cannot begin until the tool has cleared the work on the return stroke, and is said to take place very rapidly. This can be accomplished because the hydraulic drive for the feed is free of shock and the operation of the hydraulic feed is independent of ram drive. (Abstracted from a catalog issued by the makers, the Rockford (Ill.) Machine Tool Co. The information has not been checked otherwise, *d*)

A New Module System

THE module of a gear is the pitch as related to the diameter and not to the circumference. In the metric system the most familiar of the module systems, a 5-mm module, also referred to as a 5-module gear, has one tooth for every 5 mm in its diameter. Thus a 50-tooth gear of 5 mm module would have a pitch diameter of 250 mm. The author discusses other systems of specifying pitch ratios such as the diametral pitch, in decimal fractions of an inch, and a system which bases the module upon the radius instead of the diameter. The author recommends the use of the hundredth-inch as a base of the module.

The new module m, then, expresses the pitch of gear teeth as measured upon a diameter in m/100ths of an inch.

For instance, a 90-tooth 7-module bear would have its pitch diameter $90 \times 7 = 630$ modules. And since each module is m/100ths of an inch, the diameter is simply obtained by pointing off the last two ciphers. The 630 modules thus become 6.30 in.

The new modules are selected so as to give a range whose steps from pitch to pitch are commensurate with those of diametral pitches, metric modules, and circular pitches. Moreover, selection has been such that the common circular pitches are extremely well approximated.

So good is the approximation of the modules to circular pitches that circular-pitch gears can be cut with the new module disk cutters, or by any generating system, such as the Fellows, Sunderland, and hobbing. In the generating system, the error is such that the nominal pressure angle, either $14^1/_2$ deg or 20 deg, is very slightly decreased, and the tooth thickness for the same cutting depth inappreciably lessened. (H. S. in *Ma-*

chinery (London), vol. 39, no. 991, Oct. 8, 1931, pp. 45–46, including a table of the new system modules, *td*)

The McLeod-Richards Thread-Milling Machine

TWO principal methods, differing radically from each other, are employed for carrying out the process known as thread milling. The older method makes use of a cutter, on the cylindrical surface on which there is, not a thread, but a series of parallel ridges of the required thread section and pitch. The ridges are gashed and relieved to form cutting edges. Initially the cutter, rotating at a high speed, is fed radially against the stationary work. When the feed reaches the full thread depth the work is slowly rotated and is simultaneously advanced at such a rate that at the end of one complete turn it has moved longitudinally through one pitch distance. Alternatively the longitudinal motion may be applied to the cutter. In either case the initial gashes formed during the preliminary feeding-in process are extended spirally around the periphery of the work, and join up with each other to form a complete thread. The work is therefore fully threaded after it has made one whole turn.

The second principal method of thread milling is that invented by the late George Richards. Briefly, it depends on the fact that if two cylinders of the same diameter and threaded to the same pitch are engaged and allowed to roll down an incline they will arrive at the foot without exhibiting any relative endwise displacement. If then the two cylinders

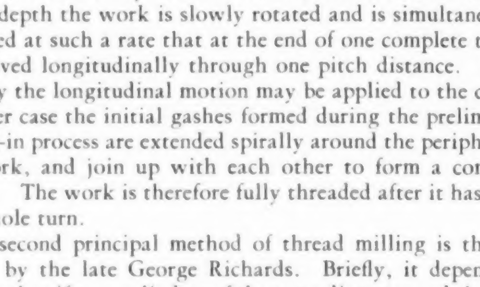


FIG. 1 EXTERNAL AND INTERNAL THREADING

are mounted on parallel axes and are rotated in the same direction at equal speeds, and if one cylinder is plain while the other is threaded and gashed, then when the one is fed radially against the other without relative endwise movement, the plain cylinder will eventually have a thread cut upon it equal in pitch to that of the cutter cylinder. The inward feed is continuous during this process, and the thread is not completely cut until after the work has made several turns. Moreover, when two cylinders are mounted on parallel axes they need not be of the same diameter.

The same principle is applicable to the milling of internal threads, except that the cutting speed is then not the same but is the difference between the peripheral speeds of the work and cutter.

In Fig. 1 external thread milling is represented at *A* and internal milling at *B*. It will be observed that, if the teeth are to excercise any cutting action at all during internal milling, they must point in the direction opposite to that in which they point during external milling. If, however, as shown at *C*, facilities exist for reversing the direction of rotation both of the cutter and the work, the cutter teeth need not be reversed in direction. This consideration opens up the possibility of employing the same cutter on internal work as on external. There is, however, an objection to this procedure. If the external and internal work are of the same diameter, the use of the same cutter will of necessity involve a lower cutting speed on the internal than on the external work, since in the one case the cutting speed is the difference and in the other the sum of the work and cutter peripheral speeds. To obtain equality in the cutting speeds the number of turns per minute made by the cutter and work during internal milling must be greater than the number of turns which they make during external milling.

There is a means of escape from this practical objection. It consists of employing on internal work a cutter with a left-handed thread and of rotating the cutter and work in opposite directions, but at the same number of turns per minute. The thread cut under these conditions will be a right-handed one and the cutter speed will, as on external work, be equal to the sum of the peripheral speeds. This system is that which is now adopted under the Richards process.

The most recent improvements deal with the difficulty in the early applications of the Richards system. In both the thread is cut in a succession of cycloidal bites and not continuously as it is in a lathe with a single-point tool. The thread, in fact, is a series of convex facets separated by ridges. In the older process the facets are very numerous and very small. Their number, and consequently their size, is determined by the number of gashes in the cutter and the ratio of the speed of the cutter to the speed of the work. As the speed ratio is high, the facets are almost undetectable. They may number anything from about a thousand to over eight thousand per thread. In the Richards process the speed ratio is of necessity unity, and therefore the number of facets becomes equal to the number of gashes in the cutter, or, say, from eight to perhaps three dozen.

R. J. McLeod's solution of the problem is embodied in the machine described in the present article and built for thread-milling tubes and couplings from 4 to 11 in. in diameter as used in the oil fields.

The screwed joints of these tubes are required to withstand a gas pressure of 2500 to 3000 lb per sq in. without the use of any jointing material. This requires great accuracy in the threads.

If the cutter has thirty gashes and if the cutter and work make the same number of turns per minute, then at the second turn of the work and cutter each gash will register with the same point on the circumference of the work as that with which it registered on the first turn. Each thread cut on the work would therefore show thirty facets. If the work were 8 in. in diameter, each facet would measure 0.838 in. from ridge to ridge. Let it be supposed that the cutter is set to rotate very slightly faster than the work, say, 301 turns of the cutter to 300 turns of the work. Then at the end of 300 turns of the work each cutting edge of the cutter will have engaged the work at 301 different points, and as a result the number of facets per thread will, it is argued, be increased from 30 to 30×301 or 9030. In practice, it is found that an increase in the speed of the cutter in the ratio of 201 to 200 is sufficient to give a thread equal to that produced in a screw-cutting lathe, and that if the speed ratio is made 1001 to 1000, the finish on the thread is of mirror-like appearance. With a 301:300 speed ratio, the facets on work 8 in. in diameter would, it is calculated, measure only 0.00278 in. from ridge to ridge.

The foregoing figures are reproduced as given by the makers of the machine, and the author of the original article suggests that the multiplication is not as large as that indicated. The application of this principle introduces a complication, namely, if the cutter makes 310 turns while the work is making 300 turns, and there is no relative longitudinal movement between the cutter and the work, then when the work has completed 300 turns the cutter will be leading by one thread, and during the acquisition of this lead it will have stripped or damaged the thread on the work. In the McLeod machine the thread is, to begin with, cut with the work and cutter running at

equal speeds. After the thread has been cut to the full depth the facets are eliminated by slightly speeding up the cutter and at the same time giving it a slightly axial movement to compensate for the stripping effect which would otherwise be present.

The machine is driven by a 25-bhp variable-speed motor which is connected to the first shaft of a gear box by means of a McLeod carrier-ring flexible coupling (not described in detail in the article).

An interesting feature of the machine is the hydraulic and mechanical control. Hydraulic power is employed to impart the transverse feed to the cutter saddle, and the hydraulic feed automatically sets itself in accordance with the resistance and is high at the start and decreases toward the end. (*The Engineer*, vol. 152, no. 3955, Oct. 30, 1931, pp. 459–462, 8 figs., *d*)

MARINE ENGINEERING

Diesel Ferry for the Delaware

THIS is a description of the ferry *Jersey Shore*. The main engine is a Diesel manufactured by the Washington Iron Works at Seattle. It has eight cylinders 18 × 24 in., delivers 925 shaft hp at 200 rpm, and weighs in the neighborhood of 100 tons.

A feature of unusual interest on the Atlantic coast, although it is employed extensively on Puget Sound ferryboats, is the arrangement of clutches which engage the propeller shaft at either end of the engine. The propeller at one end of the boat is a right-hand unit and at the other is a left-hand unit 8 ft in diameter by 7 ft 9 in. pitch. Because they rotate in only one direction, these propellers are designed for maximum propulsive efficiency while driving ahead, without special regard for backing power. The engine is unidirectional in rotation, too. It is started with both clutches disengaged and runs under governor control while idle. One propeller is started by engaging one of the clutches. As the boat is driven ahead, the other propeller spins idly. To reverse the propulsion effort, the active propeller is disengaged and the idle one is connected with the engine. By this method of backing, the full power of the engine may be applied. It is said that the friction loss of the idle propeller is about 60 hp.

The clutches are of the combination disk-cone type and are a part of the flywheels. They are operated by pneumatic-hydraulic rams and are interconnected by means of a shaft running the length of the engine and fitted with the necessary gears to operate them from the one control stand. Operation of the system has been simplified by providing enough free travel in the movement of the friction units so that a single hydraulic system serves both clutches. This means that the mechanical connections between the clutches are quite rigid, and when one clutch is shifted from neutral to fully engaged position the mechanism of the other clutch also works, but travels within the free range away from the neutral point.

The engine is heavily constructed, and in view of this the method of removing pistons through the crankcase doors is to be commended. It is not necessary to strip off any of the top hamper at any time. When the piston is taken out, the fuel-injection valve is removed to insert an eyebolt and hook up the lifting gear. The engine manufacturer states that the fuel valves as well as the main valves may be removed while the engine is in operation. A feature of accessibility of considerable importance is an arrangement by means of which the crankshaft may be removed at the side without dismantling the engine. *Motorship*, vol. 16, no. 10, Oct., 1931, pp. 531–534, 5 figs., *d*)

MECHANICS (See also Steam Engineering: Experimental Investigation of Vibrations in Turbine Wheels and Blades)

The Differential Analyzer

THIS is a machine for the solution of ordinary differential equations, and is intended for the solution of such equations of any order up to the sixth and with any amount of complexity within reason. It is said to be readily possible when plots have been made and a schematic diagram giving scales and connections has been prepared, to set up the machine for a different problem in a few hours.

The attainment of precision in a device of this sort, granted sound mechanical design and accurate construction, is largely a struggle with the problem of backlash and integrator slip. The matter of backlash is especially serious here because the interconnection of units often renders cumulative the error caused by its presence.

The general scheme of attack has been as follows: Within the drives of integrating units themselves, backlash has been substantially eliminated by the use of lashlocks. Elsewhere it has been held down to a small amount by careful construction, although a certain amount of clearance is imperative for the free running of any extensive system of shafts and gearing. In any specific problem the effect of a given backlash angle in a particular drive can then be reduced by specifying scales so that the shafts of that drive will make a large total number of revolutions in the course of a problem. In many situations this is sufficient. Finally, for important drives, where the effect of backlash might be especially serious, there has been developed a unit which can be conveniently inserted in any such drive and which reduces the influence of backlash at that point to a second-order effect. This is, in reality, a unit having a negative backlash which is capable of being adjusted to compensate for the positive backlash present in the drive into which it is inserted. It has been aptly termed a "frontlash" unit.

The underlying idea is as follows: The unit, when connected into a line of shafting, ordinarily furnishes simply a rigid driving connection from the ingoing to the outgoing shaft. When the direction of rotation changes, however, it immediately steps the outgoing shaft ahead in the new direction of rotation by an adjustable amount. This it does during part of the first revolution in the new direction. Hence for the remainder of the revolution up to the next reversal the net backlash in the total drive is brought to zero. This action is repeated at each reversal, so that there is always zero backlash in the shaft, except during the brief periods at each reversal of direction. The effect of backlash itself being small, the residual effect due to this transition period is negligible.

The details of the mechanism are shown in the original article. In tests it was found that with the backlash present the machine recorded in place of a circle a close spiral with an increment per cycle of about 1 per cent in radius. When the frontlash unit was inserted the machine was found to draw accurate circles, so that if allowed to repeat the record for several cycles the line drawn by a fine pencil point was not appreciably widened. The other features of the machine cannot be described here because of lack of space.

In conclusion the author states that the machine is not yet completed in the sense that it is questionable whether it would ever be completed, for it can always be extended by the addition of units to cover a greater order or complexity of equations. Incidentally, considerable experience is necessary to use the device effectively. (V. Bush, Dr. of Engrg., in *Publications*

from the Massachusetts Institute of Technology, vol. 67, no. 55, publication serial no. 865, Dept. of Electrical Engineering, Serial no. 75, Oct., 1931, pp. 447–488, 21 fig., *d*)

Reinforced-Concrete-Column Investigation

COMMITTEE No. 105 is in charge of this investigation by the American Concrete Institute. Its third progress report consists of reports made by two laboratories, one at Lehigh University and the other at the University of Illinois. The report from Lehigh, by Willis A. Slater and Inge Lyse, deals with the effect of amount and grade of spiral reinforcement on strength of columns, and was intended to study the effect of high-yield-point wire spiral on the strength of reinforced-concrete columns, but for comparison includes also columns having intermediate-grade spirals.

It has been found that a straight-line relation exists between the strength of the columns and the yield-point strength of the longitudinal reinforcement for both percentages and both grades of spiral reinforcement. The lines for the different percentages and grades of spirals are also practically parallel. Their straightness indicates that the effectiveness of the longitudinal reinforcement is independent of its amount. Their parallelism indicates that the spiral reinforcement is equally effective for all percentages of longitudinal reinforcement. Support has been found for the conclusion that the spiral inclusion adds to the strength of the column an amount equal to that added by an equal percentage of longitudinal reinforcement of the same yield-point stress.

The deformation of the concrete in the reinforced columns was larger than that for their control cylinders at a given stress.

Within the range of the strains measured, variation in the amount or grade of spiral had practically no effect upon the deformation of the columns.

The distances between the deformation curves for the columns of different amounts of longitudinal reinforcement correspond approximately to the distances between the curves for the reinforcement alone, indicating that in the reinforced columns the effectiveness of the concrete in carrying a load at any given strain was independent of the amount of reinforcement used.

For "fast" loading, the strength added to the columns by the spiral appeared to be approximately equal to the strength added by an equal amount of longitudinal reinforcement of the same yield-point stress.

The results from this series of tests indicate that for "fast" loading the strength of the spirally reinforced concrete column was equal to the sum of the net area of the concrete within the spiral times 85 per cent of the strength of the control cylinders, the area of the longitudinal reinforcement times its yield-point stress, and the equivalent area[1] of the spiral reinforcement times the yield-point stress of the material from which it is made.

The report from the University of Illinois laboratory, signed by F. E. Richart, Research Professor of Engineering Materials, and G. C. Staehle, Assistant Engineer of the Portland Cement Association, deals particularly with the effect of drawn wire and spiral reinforcement.

In the tests the columns with hot-rolled spirals took load very slowly near the maximum, and there was no spiral failure when the maximum was reached. Beyond the maximum, as the loading head of the machine was run down, the resistance of the column gradually decreased and finally failure of the column took place through the breakage of one or more spiral wires and an accompanying buckling of vertical bars. In the columns with drawn-wire spirals, however, failure occurred suddenly while the column was still taking load at a fairly good rate. The failure produced by the breakage of spiral wires and the accompanying buckling of vertical bars was generally violent. In many cases the concrete within several inches of the point of failure was completely shattered when the lateral restraint of the spiral was lost. While these differences in behavior of the two types of columns are a result of the method of loading the columns in the testing machine and do not indicate the action that would occur under a gravity load, they may have some significance as to the resistance offered by the two kinds of spiral near failure.

The matter of yield point of column is discussed in detail. The values were found to be practically independent of the quality of the spiral used.

The following is part of the summary to the report: With the test methods used, columns with hot-rolled spirals passed the ultimate load very slowly, without breakage of spiral. Columns with drawn-wire spirals failed suddenly and violently, due to breakage of spiral wire. The margin of strength attributed to the spirals was closely proportional to the yield point or useful limit of the two grades of spiral steel, though the drawn wire showed slightly the greater effectiveness. Drawn-wire spirals were found to average 1.99 times as effective in producing ultimate column strength as an equal weight of vertical reinforcement of the same quality. The corresponding value for intermediate-grade spirals in this series was 1.66. The yield point of the columns appears to be practically independent of the amount or kind of spiral reinforcement. The margin of strength above the yield point is naturally much greater with drawn-wire than with hot-rolled spirals, although the accompanying deformations are also correspondingly larger. The measured shortening of columns with 2 per cent of drawn wire reached as much as 1.6 per cent at failure; with similar spirals of hot-rolled rod the shortening reached 0.7 per cent at failure. (*Journal of the American Concrete Institute*, vol. 3 (*Proceedings*, vol. 28), no. 3, Nov., 1931, pp. 157–175, illustrated, *e*)

METALLURGY

Behavior of Materials Rotated in a Strong Magnetic Field

EDWARD C. HERBERT is known for his development, among other things, of the cloudburst process of hardening metals, as well as for hardening them by magnetic treatment consisting in rotating the metals in one and then another direction in a strong magnetic field.

The changes produced in magnetic hardening were originally believed to be atomic in character, and further research has strongly confirmed this view. Recent experiments indicate that the alternate softening and hardening at increasing intervals of time is a periodic effect which may be due to some pulsation taking place in the atoms themselves, and it has been attributed to a gyroscopic precession of the electrons, where a slow and rhythmic displacement of their axes of revolution, set up in the first place by the magnetic disturbance, and persisting for many hours, causes periodic fluctuations in the mutual electromagnetic attraction or cohesion which is the basis of hardness and other physical properties of the metal.

It has been found possible to set up pulsations of like character by other than magnetic means, e.g., by quenching from high temperatures and by severe cold-working processes, and

[1] By "equivalent area" is meant an area which is equal to the cross-sectional area of longitudinal reinforcement having a volume of steel per unit length of column equal to that of the spiral reinforcement used.

it seems probable that the phenomenon whose discovery was the starting point of these researches, namely, the spontaneous after-hardening which continues for some hours in hard steel which has been superhardened by the cloudburst process of bombardment with steel balls, is itself a particular phase of an atomic, that is to say, an electromagnetic, fluctuation set going by the severe mechanical disturbance.

phase of the one treated at 150 deg was selected for stabilization, and this resulted in a temporary fluctuation leading to stability at a degree of hardness high above the previous maximum. The specimen treated at 200 C was stabilized at a minimum phase, and this again caused a temporary "flutter" and stability below the previous minimum.

The principle here illustrated is expected to have important

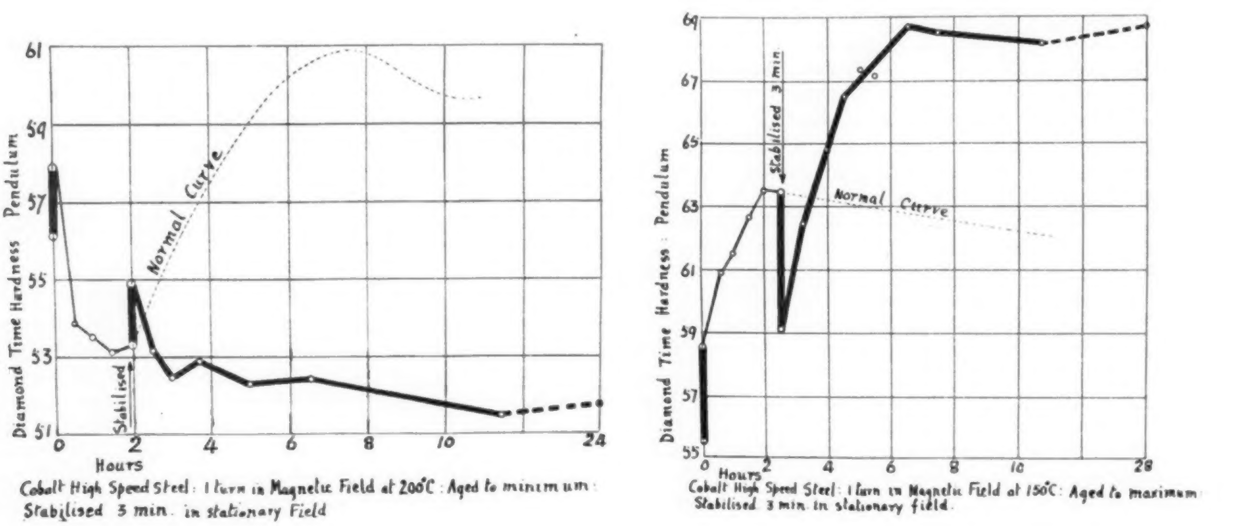


FIG. 2 GRAPHS OF APPLICATION OF ROTARY AND STABILIZING MAGNETIC PROCESSES TO HIGH-SPEED COBALT STEEL

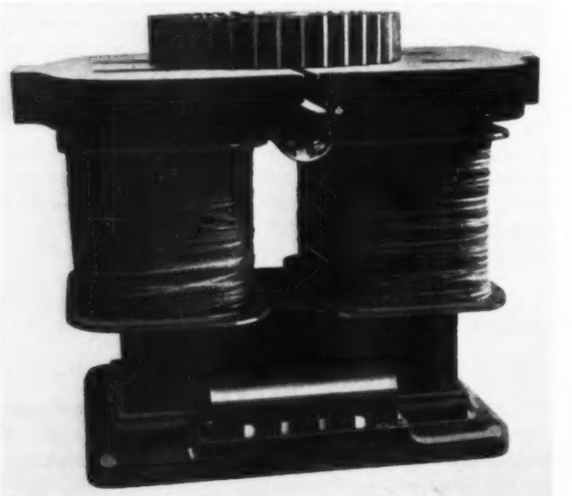


FIG. 3 MAGNETIC TABLE FOR APPLYING THE HERBERT ROTARY AND STABILIZING PROCESSES

The experiments devised to test the precession theory have led to an important practical development, namely, the invention of a secondary or stabilizing magnetic process for rendering permanent any selected phase of the fluctuations set up by the rotary magnetic process, or by thermal or mechanical means. Fig. 2 illustrates the application of the rotary and stabilizing processes to a modern high-speed steel, the "X.L.D." cobalt steel of J. J. Saville & Co., who kindly supplied the specimens in the hardened state. The graphs show the hardness fluctuations in a cobalt steel after rotary magnetic treatment at 150 C and 200 C, respectively. The "X.L.D." specimens were treated at these temperatures. The maximum

practical applications. It has been found possible to induce and render permanent a very high degree of hardness in such articles as razor blades, drills, and other tools, or to stabilize metal in the critical condition represented by the minimum phase, which is believed to be associated with physical properties of an unusual character.

Fig. 3 shows the latest magnetic table for applying the rotary and stabilizing processes. It provides a powerful field in a gap 12 in. long and adjustable in width, or, by reversing the tables, a more concentrated field in a short gap of variable width.

The rotary treatment is effected by placing the specimen across the gap and rotating it once, so as to change the direction of polarization through 360 deg. High-speed steels are usually treated hot. The most favorable temperature depends on the characteristics of the steel, but is generally not above 250 C. As the rotary treatment only occupies a few seconds, the article can be preheated in a bath and transferred to the magnet while hot. A gutter is provided to carry away any liquid that may be present.

The stabilizing process is applied cold, and consists in placing the specimen across the gap for a minute or more. It is essential that stabilization be carried out a definite number of hours after rotary treatment, being so timed as to coincide with the selected phase of the fluctuations set up by the latter. The course followed by the fluctuations will have been determined by preliminary experiment, consisting of serial hardness tests on a similar specimen.

The magnet is designed to work from the mains where direct current is available, and suitable transforming and rectifying equipment can be provided for alternating current of any voltage and periodicity. (This abstract is made in part from a letter written by Edward G. Herbert and in part from an article entitled, "Hardening Metals by Rotating Magnetic Field," in *Metallurgia*, vol. 4, nos. 19 and 20, May and June, 1931, pp. 9–13 and 47–50, 27 figs. in all)

MOTOR-CAR ENGINEERING

Automobile Operating-Cost and Mileage Studies

THIS bulletin presents the operating costs of 1675 automobiles, the records for which were submitted by individual Iowa owners and by various state highway departments. From these records estimates of average costs were determined for ten classes of cars for annual mileages of 3000 to 25,000 miles. Similar cost estimates are made for a car representing a composite of the 1930 Iowa registration.

It is recognized that most of the records kept by operators of fleets of cars do not give average costs widely applicable to cars under individual ownership and operation, or to other fleets which may be operated under a very different management and character of service. Necessarily, however, such records must be used in any successful attempt to classify costs, as complete records on personal cars are not available. Fleet records give results for high annual mileages, and thus one year of operation in such cases is equivalent to two or more under individual operation. The factors of time, unit prices, and uniformity and character of service may vary widely between the two classes of ownership, and thus any comparison must be made with allowances.

An attempt was made to collect cost reports from the owners of privately operated cars in Iowa, but it was found that few individuals kept such records. In the present investigation 208 records representing the family car were included. The methods of reduction of costs to a common basis are described in the original article. One part of the bulletin deals with the case of a two-car family from the standard of total costs only, but it is stated that the estimates of the cost of operating various classes of automobiles given in the bulletin should not be applied directly to all individual cars or even to all fleet operations.

Estimates of life mileages for 1929 give an average of 33,444 miles. This comparatively low figure is said to have been due to the fact that there was a high percentage of comparatively old cars included. A much lower figure was obtained for the cars registered in 1930.

The automobile operating-cost data are summarized in tables in the original article. These cannot be abstracted because of lack of space. (Robley Winfrey, in *Iowa State College of Agriculture and Mechanic Arts, Engineering Experiment Station, Official Publication*, vol. 30, no. 8, bull. 106, July 22, 1931, 56 pp., 12 figs., *eg*)

PIPE (See also Fuels and Firing: Transportation of Pulverized Coal in Pipe Lines and Cars)

60-In. Cast-Iron Water Conduit at Atlantic City

THIS conduit at Atlantic City, N. J., is intended for use in emergencies. The line is 9600 ft long and has a 4-ft fall from inlet to outlet.

After consideration of various materials, it was decided that a light-weight cast-iron pipe of the sand-cast type and high tensile strength would be best for the purpose except where the pipe line crossed main roads. The barrel of the pipe has a thickness of metal of 1.06 in. For crossing highways class C pipe was used in order to take care of the future heavy traffic loads at these points.

The cost of pipe and fittings delivered along the route was \$195,443.80, and of laying, jointing, piling, etc., was \$76,520.75, or a total cost per foot of \$28.33.

Unit prices were, as follows:

For furnishing and delivering 60-in. high tensile pipe, per ft. .	\$19.28
60-ft class C pipe, per ton	44.40
Class B, special casting, per ton	160.00
Excavating, laying, jointing, etc., 60-in. pipe, per ft	7.80
For hauling and placing one 48-in. valve	350.00
Ten-inch piles, oak, spruce, or pine, per ft	0.75
Longleaf yellow pine caps 10 × 10 in. × 5 ft, each	5.25

(C. G. Wigley, Civil Engr., Atlantic City, N. J., in *Engineering News-Record*, vol. 107, no. 20, Nov. 12, 1931, pp. 774-775, 3 figs., *d*)

POWER-PLANT ENGINEERING

The Use of Salts in Boiler Feedwater to Reduce Priming

PRIMING is being studied as part of the work of the Engineering Experiment Station, Ohio State University, Project No. 103.

An experimental steel water-tube boiler with the tubes entering the ends of the drum was used in the investigation, and it was discovered that the water thrown into the steam decreased as the concentration of dissolved salt in the boiler water increased. In other words, if distilled water or a very dilute solution of sodium chloride or sodium sulphate was used, a great deal of liquid water was thrown into the steam, but if the concentration of the dissolved salt was increased, less water went over into the steam, other conditions of course being kept constant. Such a state of affairs is almost unheard of, and it therefore became not only very interesting, but also very important, to find out just why this occurrence took place.

A pyrex glass boiler of the same design and nearly the same dimensions as the steel one was constructed. (Fig. 4.) A glass boiler could not of course be operated at high pressures, but since the phenomenon in question occurred at pressures of 10 lb to 15 lb and even at atmospheric pressure, the necessary conditions could be obtained.

As soon as this glass boiler was used it was seen that the reason for the strange occurrence was purely mechanical. A series of waves was propagated along the length of the steam drum, and when the crest of one of these waves hit the steam outlet, water was thrown over. It was further noted that these waves were higher in the case of distilled water or very dilute salt solutions than in the case of the more concentrated solutions. The explanation of the strange behavior was therefore at hand; the throwing of water into the steam line was due to these waves, and the waves became lower, and of course hit the steam outlet less frequently, as the salt concentration increased.

The next step was to explain why the waves were lower and flatter in the case of the strong salt solutions. The explanation is that when distilled water or dilute salt solution is boiled, the steam bubbles, though small at first, merge together into large bubbles, and when these large bubbles emerge from the water tube into the drum they set up a series of surges or pulsations which cause waves along the drum. When stronger salt solutions were employed in the boiler the small steam bubbles did not coalesce, but remained small, and therefore, when they emerged into the drum, did not set up such pulsations. In passing, it is interesting to observe that the theory explaining why bubbles produced in a strong salt solution do not coalesce to form larger bubbles, was worked out in the department of chemistry of the University.

Photographs were taken of the steam in its passage through the water tube. Exposures of about $^1/_{600}$ sec were used, and photographs were obtained showing that the small steam

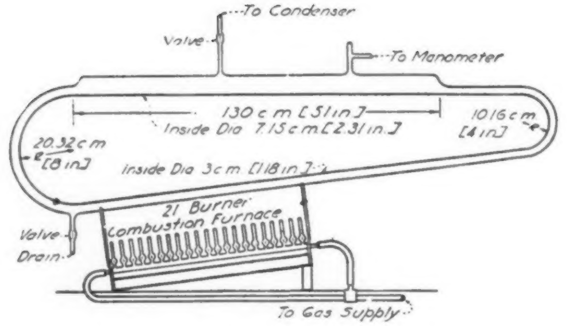


FIG. 4 EXPERIMENTAL GLASS BOILER USED IN OBSERVATION OF PRIMING

bubbles in the case of the strong salt solutions actually remained small and did not coalesce. (C. W. Foulk, Professor of Chemistry, Ohio State University; abstracted through *Heating and Ventilating*, vol. 28, no. 10, Oct., 1931, p. 67, *d*)

A Brown-Coal High-Pressure Boiler Plant

THIS plant intended for use in process steam has been erected at the Renate briquet factory of the Ilse Bergbau A. G. and consists of two 1700-lb-pressure boilers each with a normal capacity of 75,000 lb of steam per hr. It is operating at a normal pressure of from 1500 to 1600 lb per sq in. to supply steam to two 12,000-kw triple-casing extraction back-pressure turbines at normal throttle conditions of about 1420 lb pressure and 842 F temperature.

Two of the interesting features of this plant are the remarkably low water rate and flexibility of the machines. Operating against a back pressure of 50 lb and no bleeding the water rate at a load of 8500 kw. is 16.6 lb per kwh. The high-pressure part can be uncoupled and used alone, or it can be used in conjunction with the intermediate-pressure cylinder. In the first case, throttled live steam is sent into the intermediate-pressure casing. In the second case, the low-pressure cylinder works alone with 185 lb gage, 626 F steam supplied from low-pressure boilers from another plant.

At present two Borsig boilers of slightly different construction are installed. Both are built for a maximum pressure of 1700 lb per sq in. but operated at 1630 lb in order to avoid unnecessary popping of the safety valves. Both units are fired by brown coal or lignite on stokers, but auxiliary pulverized-coal firing is provided, the pulverized coal being obtained from the electrostatic dust separator in the brick works.

One of the interesting features of the turbines installed is the regulating valve and strainer arrangement described in detail in the original article. (*Power Plant Engineering*, vol. 35, no. 21, Nov. 1, 1931, pp. 1059–1060, 5 figs., *d*)

PUMPS

A New Rotary Pump

A NEW rotary displacement pump was shown at the recent Shipping, Engineering, and Machinery Exhibition at Olympia, London, England. Fig. 5 shows a drawing of the pump with the end cover removed. Within an outer casing having suction and delivery branches, a circular member with a square hole in its center and ports opening into the center on each of the four sides is connected to the driving shaft, and can rotate. A rectangular piece having ports in its shortest sides and a rectangular hole cut axially through it can reciprocate within the square hole of the rotating member. Within the rectangular hole in the last-mentioned part a square block is mounted upon an eccentric pin. Thus when the rotating member turns, the two parts within reciprocate, the alteration in the spaces between the various parts providing a pumping action which is equivalent to that of a duplex double-acting pump with cranks at 90 deg. Suction and delivery take place over an angle of about 120 deg, and the remaining arcs of 60 deg form the seal between the delivery and suction sides.

The design is such, it will be seen, that the leakage paths are long and live contact is avoided. In consequence, it is claimed that the pump has a high displacement efficiency, and the makers state that the mechanical efficiency is also high. It is suitable for running at high speeds, and can be driven by an electric motor direct coupled. The pump is made in both the vertical and horizontal forms, and is capable of pumping against heads up to 200 ft of water. It is made in a range of sizes, with

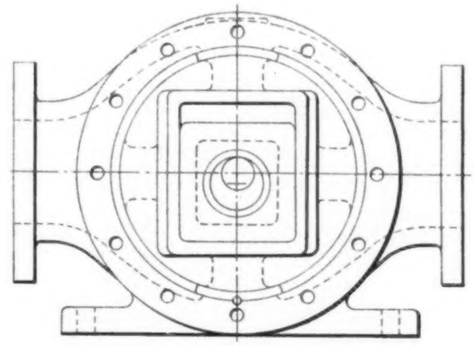


FIG. 5 THE THOMPSON BROS. ROTARY DISPLACEMENT PUMP

branches from 1 in. to 8 in. in diameter. The smallest size, running at 1100 to 1400 rpm delivers 11 gal per min, while the largest delivers 655 gal per min at 220 to 300 rpm. The speed at which the pump is run depends to some extent upon the viscosity of the oil or other liquid passing through it. (*The Engineer*, vol. 152, no. 3950, Sept. 25, 1931, pp. 317–318, 2 figs., *d*)

REFRIGERATION

Electric Refrigeration by Means of Electrolysis

THIS refrigerator, based on a development in 1908 by Prof. Kammerlingh Onnes, of Holland, of a system for condensing helium, employs the principle of electrolysis of an endothermic liquid in hermetically sealed steel tubes. No details of the liquid or the process used are given. (*Radio*, Oct., 1931, pp. 14 and 26, 1 fig., *d*)

STEAM ENGINEERING (See also Engineering Materials: Endurance Properties of Some Well-Known Steels in Steam)

The Drysdale High-Speed Steam Engine

THE practical features of this engine are that two valves are incorporated for the control of one cylinder, and that the valve chests and valve rods are placed in front instead of in line with the cylinder.

The use of the separate inlet and exhaust valves placed side

by side at the front of the engine has been selected in order to obtain from a single-cylinder engine a consumption comparable with that obtained from a compound. The use of separate valves is said to allow the compression to be controlled irrespective of the position of cut-off and to reduce steam leakage considerably; at the same time each valve can be properly proportioned to suit the steam flow through it, so that wire drawing is much reduced. The arrangement of the valve ports is stated to be such that the momentum of the steam is employed in ejecting condensed water, giving a dry cylinder at admission and a quiet-running engine. The location of the valves at the front of the engine makes it necessary to use a special construction of the valve gear, shown in a drawing in the original article.

Test figures supplied by the makers show a steam consumption of 25 lb per ihp and 29 lb per bhp with saturated steam at 200 lb per sq in. pressure. The first cost of the machine is somewhat greater than that of a conventional unit of the same size. (*The Engineer*, vol. 152, no. 3957, Nov. 13, 1931, p. 525, 3 figs., *d*)

Experimental Investigation of Vibrations in Turbine Wheels and Blades

THE authors, apparently connected with the General Electric Co., Ltd. (British), start with a general consideration of the causes and effects of vibration in steam turbines, and then proceed to the consideration of vibration of stationary and of rotating wheels. The work described was done in a special laboratory equipped by the General Electric Co., Ltd., at Fraser & Chalmers Engineering Works, Erith, Kent. In this plant there is a static tester and a blade tester. The static tester comprises a cast-iron block 14 tons in weight, set in 30 tons of concrete, this mass being necessary to prevent as far as possible vibrations of the supports. The data obtained from this static tester are not at present adequate to enable the critical speeds to be predicted with certainty, and the tester is not now used to any great extent.

The blade tester, designed to hold any size of blade manufactured, is likewise of considerable mass and set on a concrete foundation. One or more blades connected to a cover-band section can be accommodated, and tests are made to ascertain the effect of the cover band on the natural period of the blades. The blade tester can be employed to determine for each type of blade the following vibration characteristics: (1) The natural frequency in the two principal planes in the gravest mode; (2) the same in as many different modes of vibration as possible; (3) with several blades clamped by a cover band; (4) a number of identical blades may be tested to ascertain the effect of the tolerances of manufacture.

While as far as the authors are aware every other plant in existence at the present time employs steam to rotate the wheels under test, in the present installation an electric drive was preferred, the wheel running in a vacuum in order to prevent overheating due to the fan action of the blades. Another advantage of using an evacuated chamber is that by the partial admission of air any desired temperature difference can be obtained between the blades and the hub to simulate working conditions.

The methods of measurement and the details of the tests undertaken are stated in the original article. As to blade vibrations, a standard formula is known for the natural frequency of a bar clamped at one end and vibrating in a transverse direction, and the first experiments undertaken were to ascertain how far this theory could be verified. In every case it was discovered that the periodicity was about 3 per cent below the calculated value, and it is considered that this discrepancy is due to the impossibility of obtaining a mathematical rigid fixation.

The tests on rotating wheels cannot be reported here in detail.

Fig. 6 shows a typical oscillogram obtained in such a test. The transverse lines are recorded by the time marker, and represent hundredths of a second. The first record gives the speed, the second is the record of the stationary pick-up, and the third that of the rotating pick-up.

It will be observed that, on the record from the rotating pick-up, a discontinuity occurs at regular intervals of one per revolution. The cause of these disturbances is the passage of the rotating coil past the exciting magnet.

It is interesting to note, in passing, that it is probable that the one-nodal-diameter major critical speed cannot exist, and it is certainly outside practical running speeds for all wheels. For this mode of vibration, however, minor criticals have been investigated with interesting results. It will be seen that the frequency of the force required to maintain the first minor critical vibration, for instance, for this mode is one impulse per revolution, and is therefore equivalent to that produced by dynamic unbalance. Further, the fixation of the wheel on the shaft, which has little effect on other modes, is found to have a large influence, which it is not easy to forecast, on the one-nodal-diameter vibration and its minor critical speeds.

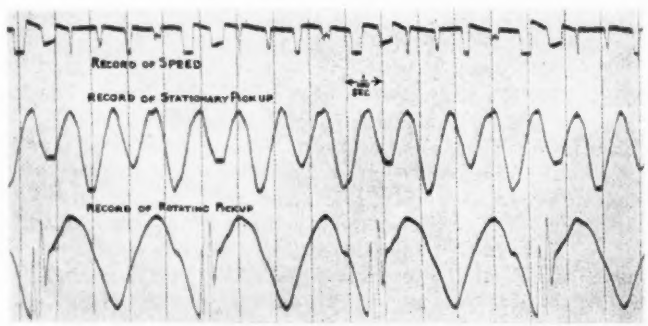


FIG. 6 TYPICAL OSCILLOGRAM IN TEST ON RUNNING WHEEL

It will be seen from the foregoing that in a turbine, conditions do exist which may give rise to critical vibration. For example, the force on the wheel due to the steam is equivalent to a continuous pressure around the periphery, but at the diaphragm joint there may be a discontinuity in the pressure, the net effect of which is that of a resultant force at each diaphragm joint.

Sympathetic vibration may also be set up in the shaft, due to out-of-balance rotational forces and the like. It is therefore apparent that the only safe course is to obtain an intimate knowledge of all the critical speeds at which wheel vibration can occur, and to design the wheels in such a manner that there is, in all cases, a safe margin between the criticals and the running speed.

The original article gives some actual test results, as an example of which is cited the case of a wheel 9 ft in overall diameter and having a bore of 21 in. for a turbine running at 1500 rpm.

The article describes how a general reduction in the values of the critical speeds was effected by tuning the wheel, with the percentage greater for the lower nodal diameters.

The characteristics of the wheel after tuning are given in the original article, and the question is discussed how far readings

in the dynamic tester in the laboratory represent the frequencies of vibration in an actual turbine.

An experiment was made to obtain information on this point with a turbine of 30,000 kw capacity at the Hams Hall generating station of the Birmingham Corporation. In this turbine the critical speed of the two-nodal-diameter vibration occurred in the dynamic tester at 21.3 rps, corresponding to a forward wave frequency of four cycles per revolution or 85.2 cycles per sec. In the two records on the actual turbine vibrations were obtained at 21.38 rps and 21.6 rps, respectively, and each had a forward wave frequency of four cycles per revolution. This is prima facie evidence of a two-nodal-diameter vibration and provides a remarkably close check on the results given by the dynamic tester.

Natural extreme conditions of temperature difference do not exist during running up to speed, as there is no load on the alternator. The final test, therefore, was to run the turbine on load for some time and at overspeed. No critical vibration could be obtained. (B. Pochobradsky, W. Jolley, and J. S. Thompson in *Engineering*, vol. 132, no. 3433, Oct. 30, 1931, pp. 541–545, and 2 sheets of illustrations, *eA*)

Tests of a Mono-Compound Bleeder-Type Steam Engine

THIS article describes tests of a compound bleeder-type engine. The machine has two single-acting cylinders with a differential piston, and because of its shape and general action has been called by the designer "mono-compound." Its arrangement is shown in a general way in Fig. 7. The rear cylinder, which is a high-pressure one, is equipped with admission and exhaust piston valves of conventional design. The forward cylinder is a low-pressure one discharging into a vacuum. In order to obtain a very wide range of cut-offs, the high-pressure admissions can be pushed very far—to more than 90 per cent of the stroke—while the admissions at the lower-pressure end can be reduced to zero. Just as in any cut-off compound engine there is an advantage in reducing the consumption of the low-pressure cylinder, which is therefore equipped with exhaust facilities by means of simple open ports which reduces the internal condensation. In addition to the lower first cost the following advantages are claimed for this arrangement as compared with the conventional compound engine: First, only the extreme ends of the machine are hot while the middle part is cold, and hence its loss of heat is at a minimum; second, the distribution is simplified, as instead of eight valves, as in an ordinary compound engine, only three are used; third, the number of packing glands is reduced to one, located between the low-pressure steam and the outside air. A tandem engine has at least three of them, one at high temperature between the high-pressure cylinder and the outside air, and apt to cause important losses.

The engine with which the present tests have been carried has the following dimensions: High-pressure-cylinder diameter, 300 mm (11.81 in.); low-pressure-cylinder diameter, 500 mm (19.68 in.); stroke, 600 mm (23.62 in.) speed, 130 rpm; steam bled to receiver at a pressure of about 2 kg per sq mm gage (0.284 lb per sq in.).

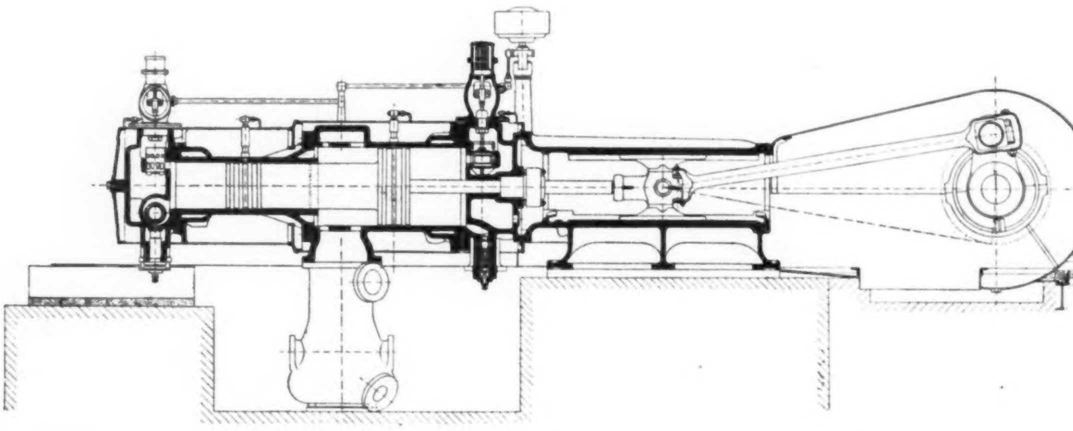


FIG. 7 LONGITUDINAL SECTION OF MONO-COMPOUND STEAM ENGINE

Two consumption tests were carried out, one with superheated steam and the other with saturated steam and with different amounts of bleeding. The results are given in Table 2.

It would appear from this that the consumptions of steam per unit of power, less bleeding, are very much less than in conventional engines, as they correspond to less than 1.6 kg of steam (3.53 lb) or less than 250 g of coal (0.55 lb) per ihp-hr as soon as the bleeding amounts to more than 1200 kg (2646 lb) per hr. On the other hand, when the power output is increased and the bleeding pushed to the maximum, very characteristic diagrams, such as those shown in Fig. 8, are obtained. These diagrams have been taken with saturated steam and a power output of 150 hp, and correspond to a bleeding of 1700 kg (3748 lb) of steam per hr. This is said to be a really remarkable result as it corresponds to a consumption of coal of less than 200 g (0.44 lb) per ihp-hr, after deduction of heating.

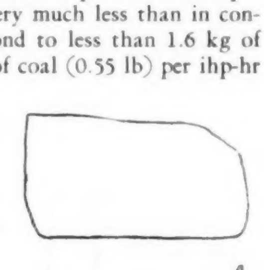


FIG. 8 INDICATOR DIAGRAM OF THE MONO-COMPOUND STEAM ENGINE FOR A TOTAL OUTPUT OF 140 HP AND BLEEDING OF 1700 KG

(Upper figure: Hp, scale 2 mm per kg; lower figure: Effective pressure, scale 5 mm per kg.)

The test data are of interest as they call attention to a somewhat novel type of engine, and particularly one especially suited to a condition where process steam is required as well as power. The original article contains a chart which makes it possible to calculate rapidly the consumption of steam per indicated horsepower of a mono-compound engine of the type described as a function of the power and the bled steam. The curves are drawn for hourly bleeding ranging in amount from 750 to 1600 kg.

TABLE 2 TESTS OF MONO-COMPOUND STEAM ENGINE

	Superheated steam	Saturated steam
Duration of test, hr-min	7–30	7–30
Absolute pressure at admission, kg	13.01	14.18
Temperature at admission, C	216	192
Absolute pressure at bleeding, kg per sq cm	3.11	3.25
Absolute pressure at exhaust in low-pressure cylinder, kg per sq cm	0.140	0.141
Power output of high-pressure cylinder, hp	86.2	98.4
Power output of low-pressure cylinder, hp	11.7	14.7
Total power output, hp	97.9	113.1
Speed, rpm	133	133.5
Admission at high pressure, per cent	55	55
Admission at low pressure, per cent	3	3
Total consumption per hour, free of conduit losses, kg	998	1400
Bleeding at receiver per hour, kg	791	1220
Measured hourly consumption, low pressure, kg	207	180
Specific consumption per hp-hr less bleeding, kg	2.12	1.59

(H. Mouchelet, Managing Engr., Northeast Association, France, in *Bulletin des Associations Françaises de Propriétaires d'Appareils a Vapeur*, vol. 12, no. 45, July, 1931, pp. 179–184, 4 figs., *deA*)

SPECIAL MACHINERY (See also Mechanics: The Differential Analyzer)

A Nut-Forging Machine

THIS machine for making blanks for "black" nuts is the invention of H. Maplethorpe, of West Bromwich, Birmingham, England, and is claimed to make nuts with very little scrap. In the ordinary process of stamping out hexagonal nut blanks from a rectangular bar the waste represents about one-third of the total material. In the case of $^1/_2$-in. nuts the latter consists of pellets about $^1/_8$ in. thick and weighing ten to the ounce. A further advantage is that the nuts are made from round bar stock, which is generally more readily available than a specially sized rectangular section. The process consists in pressing a hot cylindrical blank out into the salient angles of a hexagonal die and punching a central hole, in a series of five operations—see Fig. 9.

A hot blank *A* is brought into position by a carrier *B*, in front of the die *C* in the plate *D*. This die is backed up by the bolster *E*, and into it the blank is pushed by the ram *F*. The plate *D* then moves one step forward and the ram *G*, advancing, squeezes the blank out, more or less, into the hexagonal form of the die *C*. There is another step and a punch advances, which not only partially perforates the blank—for the bolt hole—but also pushes out the material to fill the corners of the die. At the next step a longer punch completes the perforation against the hollow bolster, and produces little wads. These wads are led away to the waste bin, and the final step is made, the finished nut blank being expelled through a larger opening in another bolster.

The machine has the general characteristics of a bending or forging machine. The tools are arranged around a circular collar. In front of the tool head there is a die plate which is rotated step by step by a rachet gear and eccentric. By this intermittent motion of the die plate, the dies, which are filled with hot blanks, are brought into position for operation upon by the tools in the slide shown in Fig. 9. The details of the method by which the hot blanks are fed into the machine are described in the original article. (*The Engineer*, vol. 152, no. 3597, Nov. 13, 1931, p. 515, 4 figs., *d*)

SPECIAL PROCESSES (See Engineering Materials: Fusible Alloys in Metal Forming)

THERMODYNAMICS

Batch Heating With a Variable-Performance Heat Pump

THE author briefly describes a process in which a refrigerating machine is used for heating purposes. Essentially the idea is not new as the heat pump has been the subject of a good deal of attention lately.

The disadvantage of all such apparatus has been the cost of the extra equipment involved. The author claims, however, that much better performance efficiencies, amounting to double those found by previous investigators, can be obtained by heating the material in batches and allowing the temperature of the condenser to increase gradually with that of the body being heated instead of maintaining a constant temperature in the condenser corresponding to the maximum temperature required in the medium to be heated.

The author lays down the general conditions for a heat pump working between two temperatures, and describes a series of tests which he performed.

In order to verify this variation of efficiency with changing temperatures of the condenser, a small "Frigidaire" refrigerator was set up to heat water as in Fig. 10, using sulphur dioxide as the heating medium. The one-horsepower motor used was supplied through an electric meter, and drove the compressor with a V-belt. This compressor had two cylinders working in parallel (bore, $2^1/_8$ in.; stroke, $2^1/_4$ in.; rpm, 370), and drew off the SO_2 gas from the boiler (5.65 sq ft heating surface) which was immersed in a tub of water. This water was kept in circulation and maintained at about 75 F.

The compressed SO_2 gas was run through a lagged pipe into a condenser (8.73 sq ft heating surface) which was immersed in 52 lb of water, being one batch to be heated. After discharging the latent heat into this water, the condensed SO_2 was run back through the float-operated valve *X* into the boiler, to be evaporated again and redrawn into the compressor suction in a continuous circuit.

Before commencing to heat, suppose that the temperatures and SO_2 pressures of all parts of the system are constant.

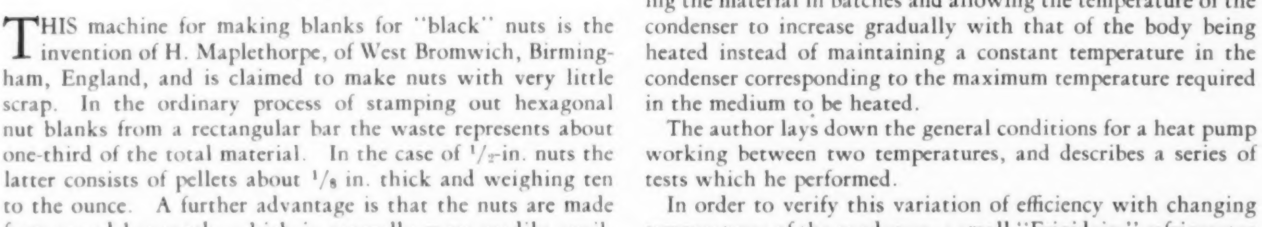


FIG. 9 SEQUENCE OF OPERATIONS IN FORGING NUTS IN THE MAPLETHORPE MACHINE

When the compressor is started up it draws SO_2 gas from the boiler *B* and drives it into the condenser. As this gas is compressed into the condenser its temperature is raised, the heat is taken up by the surrounding water, and the gas is condensed to liquid SO_2. At the point of starting very little energy is expended in compressing the gas. The amount of work done by the compressor increases with the temperature of the condenser. The boiler temperature remains practically constant with a constant level of the liquid SO_2 and maintains a fairly constant evaporating rate. The increased pressure produces a tendency for the liquid SO_2 in the condenser to flow through the float valve into the boiler *B*. As the compressor removes the gas from the boiler the pressure falls until the SO_2 boils, absorbing latent heat from the water. At the same time, transfer of the

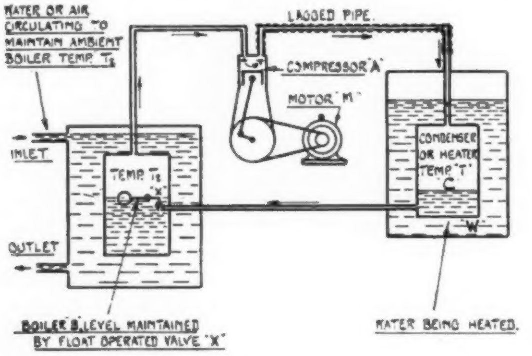


FIG. 10 SCHEMATIC LAYOUT OF HEAT-PUMP PLANT USED IN THE EXPERIMENTS

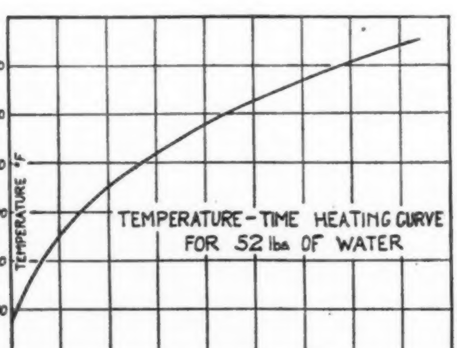


FIG. 11 TEMPERATURE-TIME HEATING CURVE FOR 52 LB OF WATER

liquid SO_2 from the condenser to the boiler takes place, due to the fall in level of the liquid in the boiler. The temperature of the condenser is increased a few degrees above that of the water being heated, depending upon the amount of heat to be transferred, and upon the heat-flow rating of the condenser. When the water surrounding the condenser has reached the temperature desired, it is run off and another batch is run in to be heated up in the same way.

The results of the tests with the refrigerator as a heat pump are given in the original article and are shown there in Fig. 5, where they have been corrected for motor inefficiency and are compared with the results theoretically obtained from an ideal heat pump. These curves show that very high coefficients of heating performance are obtained during the initial stages of the heating process. An examination of the temperature-entropy diagram reveals the reason therefor. This also appears in the original article.

Performance efficiency is greatly increased when the weight of water being heated is large compared with the weight of those parts of the apparatus which have to be heated as well. Such parts comprised the compressor head, piping to the condenser, condenser, and SO_2 contained in it, due to this added material having to be heated up without the heat being usefully supplied to the water. This carry-over heat is available for the next batch of water to be heated, and although it heats the water up at a reduced coefficient of heating performance, it would have improved the test figures if it had been included, which was not the case in these experiments.

A curve in the original article (Fig. 7) shows the efficiency of the pump in comparison with the theoretical ideal. This shows a much higher value for the plant when working under

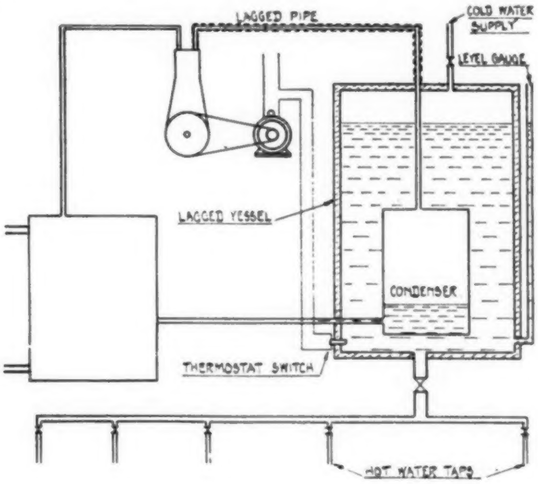


FIG. 12 GENERAL ARRANGEMENT FOR HEATING WATER IN ONE BATCH

batch conditions, though all the values are low, due mainly to the apparatus being designed to dissipate heat where it was desired especially to conserve it.

With a constant boiler temperature, and with the condenser temperature increasing as the heating progresses, the rate of heating depends on the latent heat of the gas discharged to the condenser. With SO_2 and other substances used, this latent heat decreases as the temperature increases, so that a slowing up should be expected at higher temperatures. Fig. 11 shows the increase of temperature with time.

Fig. 12 shows the batch-system heat pump connected to a hot storage system, wherein the condenser is placed in a lagged vessel. The water is heated in one batch and is drawn off as it is required until it is empty, when another cold batch is run in and heated up ready for use. (Jas. Cyril Stobie in *Journal of the Institution of Engineers, Australia*, vol. 3, no. 8, Aug., 1931, pp. 279–283, 10 figs., *tde*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

SYNOPSES OF A.S.M.E. PAPERS

THE papers abstracted on this and following pages appear in the current issues of the Aeronautics, Applied Mechanics, Hydraulics, Fuels and Steam Power, Machine Shop Practice, Petroleum, and Wood Industries sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering."

AERONAUTICS

Stability and Controllability in Free Flight

MAKING the airplane pleasant to fly is discussed by the author in this paper. Strength, durability, and performance of airplanes are determined quite accurately by analyses and tests, but the ease with which a particular plane can be maneuvered is often left to chance. Stability at cruising speeds and balance with the throttle closed and open are essential for ease of control. The author tells of various methods that can be used to test flying characteristics and make certain that airplanes will perform as desired. (Paper No. AER-53-10, by Paul E. Hovgard.)

Opportunities for Aviation Training

IN THIS paper the author endeavors to set forth the possible methods of obtaining adequate instruction and training to enter the aviation industry either as a pilot or in a ground capacity. The paper is written from the practical viewpoint of training facilities available in the industry itself rather than opportunities presented by strictly educational institutions such as secondary schools and universities. The author also points out some of the advantages and disadvantages that are apparent in the existing means of obtaining aviation training. (Paper No. AER-53-11, by Joseph S. Marriott.)

Management and Operation of a Large Airport

THE policies and methods outlined indicate how an airport may be managed so as to take care of all interests. The author covers relations of the airport management with transport companies operating large fleets, with air-service operators having fleets of taxi and charter planes, with schools, with dealers and distributors, with manufacturers, with private owners of airplanes, with individual owners of single airplanes or small fleets for business purposes, and with the general public. Figures are given showing how a successful business has been built. (Paper No. AER-53-12, by Waldo D. Waterman.)

Airplane-Instrument Vibration

THIS is a report of the A.S.M.E. Special Research Committee on Airplane Vibration With Special Reference to Instruments. The problem is one of vital interest to both aircraft manufacturers and operators, since safety in flying depends to such a large extent on accurate instruments. The present investigation, of a preliminary character only, had for its purposes: (1) The securing of information on difficulties encountered in practice, (2) the collecting of opinions as to possible remedies, and (3) formulating suggestions for research.

With these purposes in mind, the committee sent out a questionnaire to pilots, airplane operators, aircraft manufacturers, aircraft-instrument makers, and others in the aviation industry.

A survey of the replies received shows that comparatively little is known as to the exact cause or causes of instrument vibration. The following items, however, stand out:

1 That instrument vibration is not limited to any type of plane, fuselage construction, engine mount, or engine or propeller make.

2 That changes in fuselage structure or engine mount are not considered essential.

3 That instrument vibration is not necessarily limited to specific engine speeds.

4 That practically all instruments are equally affected by vibration.

5 That partial elimination of vibration difficulty may be obtained by placing the instruments as far away from the engine mount as is conveniently possible.

6 That elimination of vibration difficulties may be found by proper mounting of the instrument board and instruments, and perhaps further refinements in the instruments themselves. (Paper No. AER-53-13.)

APPLIED MECHANICS

On Problems in the Theory of Fluid-Film Lubrication, With an Experimental Method of Solution

ANALYTICAL treatment of problems in perfect film lubrication is in general very difficult; solutions have thus far been obtained only in a few relatively simple cases. The paper describes methods by which fairly accurate solutions of any stated cases may be obtained experimentally, through the analogy between electrical potential and current flow in a conductor and pressure and volume flow in the lubricating film. Electrical measurements are made upon enlarged models of the lubricating films, the models being bodies of conducting fluid contained in wooden boxes having forms determined by theory. Pressures at points in a film having been deduced from the electrical data, graphical or other means of integration are used to determine the total load, the friction, and the quantities of oil flow at the edges of the film. The method is not limited as regards the shape of the film or variation of viscosity within the film. Solutions are given for a number of cases of plane bearing surfaces and journal bearings, showing close agreement with analytical solutions in cases where the latter have been obtained. (Paper No. APM-53-5, by Albert Kingsbury.)

Stresses in Retaining and Centering Rings for Turbine-Generator Rotors

IN THIS paper the authors deal theoretically with the distribution of stresses throughout the system of parts enclosing the rotor coil ends of a turbine generator.

This system of parts consists of a disk of uniform cross section, a cylinder, and a part of the shaft. These parts are fastened together by means of fairly heavy shrink fits, and therefore, in the development of formulas for the stresses, the effect of this shrinkage, as well as that of rotation, must be considered.

Since these parts must remain integral for the design considered, the importance of being able to predetermine the speeds at which the various parts may become free is apparent. Therefore formulas were developed for these speeds subject to the boundary conditions which were set up.

An example is given for which the distribution of stresses for two cases is plotted. These two cases are, respectively, for the generator at standstill and at operating speed.

A summary of the significant results is given at the beginning, and a discussion of the main points of interest at the close of the paper. (Paper No. APM-53-6, by R. Patterson and D. H. Harms.)

Determination of Stresses in Rotating Disks of Conical Profile

IN THIS paper a determination is made of the accuracy of stress-distribution curves obtained by the application of Donath's "Sum and Difference Curves" to rotating disks of conical profiles. (Paper No. APM-53-7, by F. C. Rushing.)

Elastic and Inelastic Behavior in Spring Materials

IN THIS seventh Progress Report of the A.S.M.E. Special Research Committee on Mechanical Springs (Technological), are described the results obtained to date in connection with the more fundamental studies of the elastic behavior of spring materials. These results may be summarized in part as follows:

1 A new method of work has been adopted, by which a greatly increased order of accuracy has been obtained in studies of behavior of spring materials in tension. In most cases the controlling factor in accuracy tends to be the error resulting from the irregular plastic permanent yield, and from the gradual elastic or pseudo-elastic creep and recovery in the wire itself when loading and unloading.

2 Measurements obtained by this method have confirmed in general the tentative conclusions suggested in Progress Report No. 5. In particular it is now possible to give numerical values for the rate of change of Young's modulus of elasticity with stress for several materials.

3 Tests have confirmed the general principle of a decrease in modulus of elasticity in tension as a result of previous overstrain in tension. This is an important reason for more or less erratic variations in stiffness of springs resulting from overstrain, as in surging.

4 Work has been started on studies of the elastic after-effect, and mechanical-hysteresis values for unidirectional stress in tension have been obtained for several additional samples of various materials. Enough data have been obtained to serve as a basis of comparison in further studies of the relative suitability of various materials and of the effect of various types of cold work or heat treatments. (Paper No. APM-53-8, by M. F. Sayre.)

HYDRAULICS

Federal Relations to Water-Power Development

WITH the amazing advances made in the production and distribution of electrical energy during the past decade, it is of interest to examine the part played by the Federal Government. This is particularly true of the water-power field where, through vast land holdings and constitutional authority in respect to navigation, the National Government exercises control over a large portion of the country's potential resources. During this period the administration of the law regulating the utilization of power sites involving Government interest has reposed with the Federal Power Commission. Although developments of many of the large rivers have been delayed by legislative embargoes and political controversy, the Commission has authorized the construction of many important projects, and about 2,600,000 hp of capacity is now operating under license from the Commission. The proper division of authority between the Government and the states has raised some complex problems which are pressing for solution. (Paper No. HYD-53-1, by Frank E. Bonner.)

Calibration of a Large Nozzle

IN TESTING large centrifugal pumps it is difficult to determine the amount of water that is being handled. In many cases the quantity is so great it is almost impossible to determine it by the ordinary field weighing system. The use of standard test nozzles offers a simple means of determining the capacity of large pumps, but the nozzles must be accurately calibrated. The authors made a test of three pumps by laying about 1000 ft of pipe behind a dredge and attaching standard nozzles to the end of the pipe line for calibration purposes. The quantity of water flowing was determined by the salt-solution method. (Paper No. HYD-53-2, by John R. DuPriest and James H. Polhemus.)

A Method for the Standardization of Centrifugal Pumps

IN THE author's opinion, the combined application of the preferred-numbers idea and the law of similitude provides an effective means of eliminating unnecessary variety of sizes and of simplifying tool and machinery equipment in any field of industrial production.

In the application of this method to the standardization of centrifugal pumps, the author develops a set of geometric series conforming to the preferred-numbers table. The formation of the series, and their interconnection and use for treating the standardization problem, are illustrated by numerical tables, charts, and diagrams.

Standardizations of hydraulic and mechanical parts of centrifugal pumps are tied together by the use of the law of similitude, resulting in the formation of a set of interconnected geometric series applicable to both cases. (Paper No. HYD-53-3, by Jos. S. Stepanov.)

Application of Hydraulic-Laboratory Researches

THIS paper presents results of laboratory investigations made in connection with hydroelectric power-plant designs, the problems encountered leading up to the establishing of a policy of conducting research, the method of testing, and comparisons of laboratory and field results. The object is to illustrate the many advantages of model investigations and to point out the deficiency of scientific knowledge incidental to power-plant design, with the hope that interest will be stimulated in pure-science research. Hydraulic research may be classified under two subdivisions: complex flows created by natural active and reactive forces, such as river channels, harbors, estuaries, tidal effects, etc., and, second, manufactured structures, such as spillways, canals, penstocks, hydraulic machines, etc., where the active and reactive forces should be definitely predicted by the designer. This paper deals with the latter, principally in connection with hydraulic turbines and

their associated parts. (Paper No. HYD-53-4, by Ireal A. Winter.)

FUELS AND STEAM POWER

Frictional Resistance and Flexibility of Seamless-Tube Fittings Used in Pipe Welding

THE trend toward the use of welded piping has led to the development of seamless-tube fittings. These fittings are a decided departure from both the cast fittings and long-radius pipe bends heretofore used, and their introduction has occasioned considerable speculation as to their relative merits and correct application. This paper is confined to a discussion of: (*a*) the relative friction loss in elbows and bends of different radii, and (*b*) the relative flexibility of pipe lines made up with long-radius bends as distinguished from cast fittings and from seamless-tube fittings having a radius of $1^1/_2$ pipe diameters. The authors have compiled and analyzed the available data on friction loss in elbows and bends, and present a detailed comparison of the flexibility of piping made up with seamless-tube fittings, long-radius bends, and cast fittings. Seamless-tube fittings ($R/d = 1^1/_2$) are found to compare to advantage with the older types of construction in both phases considered. (Paper No. FSP-53-17, by Sabin Crocker and Arthur McCutchan.)

Corrosion Tests on Condenser Tubes

THIS is Progress Report No. 4 of The A.S.M.E. Special Research Committee on Condenser Tubes presented at the annual meeting in 1929, the report of the committee included evidence that the circulating water in certain surface condensers carried a quantity of air, both in the entrained and dissolved conditions. A series of tests was made to determine the extent of the effect of air on tube material. The method used was to make comparative corrosion tests with solutions saturated with air and under vacuum.

In consideration of the fact that all chemical reactions such as found in condenser-tube corrosion are ionic, an electric current was used in the laboratory tests to accelerate the corrosive action. Cells were made, using Admiralty brass anodes and copper cathodes. These comparative tests were made on a series of solutions ranging in concentration from zero parts per million to 26,000 parts per million of potassium chloride. From the data obtained it is clear that air decidedly accelerates the rate of corrosion. It is true that its effect is not constant at all concentrations, but its effect is of sufficient magnitude at all concentrations to make its presence undesirable. Another feature which developed in this investigation is the tendency of Admiralty brass to dezincify. It appears that a point of maximum is reached at intermediate concentrations. Particulars are given in the report regarding instances of tube failure due to corrosion which have been brought to the attention of the Committee. (Paper No. FSP-53-18.)

Heat Absorption in Water-Cooled Furnaces

BASED on the furnace heat balance, an empirical "effectiveness factor" is derived for water-cooled surfaces therein, relating the heat radiated by the burning fuel and products of combustion to the furnace-outlet temperature. The value of this factor is calculated from certain experimental data for turbulent horizontally fired pulverized-coal furnaces with bare water-cooled tube walls. For these experimental data, the fraction radiated of the heat liberated in the furnace has also been calculated and is compared with Broido's curve and with the value calculated by the Orrok-Hudson formula. The method of applying the effectiveness factor to design problems is illustrated by showing the effect of preheated-air temperature upon the furnace-outlet temperature. (Paper No. FSP-53-19a, by Wm. L. DeBaufre.)

Radiant Heat Transmission Between Surfaces Separated by Non-Absorbing Media

FUNDAMENTAL laws of radiation from solids have been discussed and applied to individual problems of heat transfer in numerous papers. In this one the author indicates just what principles are involved, to how many problems they have been applied, and gives a number of applications of the principles to problems in industrial-furnace design.

Fundamental principles and definitions discussed include: The definition of normal intensity, Lambert's cosine principle, relation between intensity and emissive power, the square-of-the-distance law, Kirchoff's law, and the Stefan-Boltzmann law. Various surface arrangements are divided into two groups: (1) in which one of the two surfaces is small relative to the distance separating them, and (2) in which both surfaces are of considerable extent relative to their distance apart. Various cases of these and the effect of incomplete absorption are treated mathematically. The task of applying many of the equations given in the paper is simplified by presentation of numerous graphs. (Paper No. FSP-53-19b, by H. C. Hottel.)

Operation of the Holland Station

THE Holland Station, being among the first plants designed exclusively for high-pressure steam, is now in operation, and the experiences obtained during operation will be of interest. The main features of the plant are a 55,000-kw cross-compound turbo-generator unit designed for variable-load operation; two similar boilers, each with its reheater built integral, designed for generating 250,000 lb of steam per hr each; elimination of the wall between turbine and boiler room, and control centralized on the operating floor. The operating experiences with the different elements of the plant are given, together with data showing the operating results for the six-month period. Operating results, while of short duration, show justification of the use of higher pressures from an economic standpoint. (Paper No. FSP-53-20a, by E. M. Gilbert.)

Operating Experiences, Deepwater Station

THE physical characteristics of the Deepwater Plant are described, emphasizing only those details which are relatively new or those which have had a distinct bearing upon operating experiences. The paper gives a history of the operations from the time the plant was first started in March, 1930, up until the present, summarizing the difficulties that have been encountered and attempting to segregate them between those that are directly chargeable to the pressure or temperature and those which have been encountered due to other features of design. Due to the fact that a large portion of the plant has been in what might be termed commercial operating service only since June 1, or for three months at the time this paper was prepared, very little authentic data on operating efficiencies can be given. (Paper No. FSP-53-20b, by K. M. Irwin.)

Comparative Resistance of Refractories to Coal-Ash Slags

THE results presented in this paper were obtained in an investigation conducted by the Engineering Experiment Station of the University of Illinois. Tests have been made in the laboratory slagging-test furnace of various commercial

refractories and of a series of special mixtures representing clays from three manufacturing districts, as well as differences in the method of fabrication, the firing treatment, and the fineness of grinding of the materials. The slags used were ashes from coals of five different districts. The comparative resistance of refractories varied with the character of the coal ash. Dry-pressed and stiff mud bricks were more resistant than handmade refractories. A moderate degree of firing treatment was preferable to hard burning when the brick were subjected to high furnace temperatures and slag action. (Paper No. FSP-53-21, by R. K. Hursh.)

Action of Slags on Firebrick and Boiler-Furnace Settings

THE results contained in this paper were obtained in an investigation conducted by the Columbus branch of the U. S. Bureau of Standards for the A.S.M.E. Special Research Committee on Boiler-Furnace Refractories. The authors present a rational discussion of the action of coal ash upon boiler-furnace refractory walls and show the consistency of results from their laboratory slag tests with firebrick under actual service conditions in boiler furnaces. (Paper No. FSP-53-22, by T. A. Klinefelter and E. P. Rexford.)

High-Pressure Chemical System for Boiler-Water Conditioning

IN THIS paper the author describes the high-pressure phosphate system for boiler-water conditioning as used at the Kips Bay Station of the New York Steam Corporation. He believes that it solves the problem of economizer deposition, and while the primary object is to avoid deposition of scale in economizers and feed lines, it is apparent that it gives a flexibility of control superior to that obtained by adding the chemical directly to the feedwater heaters or hotwells. The paper does not discuss the chemical phases of the problem. (Paper No. FSP-53-23, by A. A. Markson.)

Furnace-Gas Compositions and Temperatures in Underfeed-Stoker-Fired Boilers, and Their Effect on Boiler Settings

THIS paper is a study of conditions encountered in boiler furnaces using underfeed stokers. It includes the development of methods of test procedure and their application in investigating furnace-gas compositions, and of determining the temperatures to which the refractories of the setting are subjected. It contains a discussion of the effects of variation of the fuel-bed thickness on the brick in the settings, the efficiency of combustion, and the resultant superheated-steam temperatures. The paper further shows the widely divergent furnace-gas compositions which may be obtained directly over the fire along the wall in underfeed-stoker-fired installations. (Paper No. FSP-53-24, by A. C. Pasini and E. M. Sarraf.)

South Amboy Plant of the Jersey Central Power and Light Company

THE Jersey Central Power & Light Company, an operating unit in the Middle West Utility System, has just put into operation a new plant on the Raritan River at South Amboy, N. J., designed and constructed by the Electric Management & Engineering Corporation of New York City. This plant at present consists of two 25,000-kw vertical-compound turbines with condensers and all auxiliaries and three 280,000 lb of steam per hr boilers, furnaces, and accessories, operating at 1400 lb pressure. Space has been provided for the installation of a third turbine within the station which is approximately 168 ft square and 110 ft high to the boiler-room roof and is constructed along modern architectural lines.

The plant is located at the geographical center as well as the load center of the system and will, when the transmission lines are completed, serve as a base-load plant for both the Northern and Southern divisions, which at the present time are operated as independent divisions. (Paper No. FSP-53-25, by R. C. Roe and J. P. Mailler.)

Combined Heat and Power Supply in Industrial Plants

THE industrial plant which has a large demand for process steam has a natural advantage over the condensing central station, in that the latent heat in the exhaust is utilized, and the cycle efficiency of the prime movers is 100 per cent. The quantity of power which can be generated so economically is limited by the demand for exhaust steam, but can be materially increased by raising the throttle pressure.

There are few industries which can generate their entire power requirements, at all times, in all seasons, as a by-product of their process steam. There are still many such plants which generate power in condensing prime movers, but the vast majority purchase their requirements from public utilities.

The most significant trend in the industrial power field today is the cooperation of public utilities with manufacturing plants to develop "by-product" power to its economical limit. An example of such cooperation is cited in which the power output of an industrial plant is increased from 5500 kw to 25,500 kw, the surplus power being distributed to other consumers, over the transmission lines of the public utility. The fuel cost of the additional 20,000 kw is less than 4500 Btu. per kwhr. The combination results in a decrease of 10 per cent in capital cost and a decrease of 20 per cent in fuel consumption, as compared with the separate generation of electricity by the public utility and of power and heat by the industrial plant.

Gratifying progress has been made in the conservation of fuel by developing the high-temperature end of the industrial power and heat cycle. An enormous quantity of potential energy is still being dissipated in the relatively low-temperature wastes from our manufacturing plants. For the present, the high-temperature field offers more attractive return on investment, but the future will undoubtedly see much progress in the recovery of heat at low temperatures. (Paper No. FSP-53-26a, by W. F. Ryan.)

Engineering Aspects of Interchange of Power With Industrial Plants

ECONOMICAL operation can be effected and overhead costs greatly reduced in a great many cases where public-utility or other steam-generating or hydro power plants find it possible to hook up with large industrial operations. The advent of high steam pressures has largely increased these possibilities and extended the engineering problems involved in their proper solution. The engineer must seek the maximum overall economy with minimum investment, having regard for reliability of service, and then work out a plan for the undertaking that will be to the equal advantage of all parties at interest. (Paper No. FSP-53-26b, by B. F. Wood.)

Combined Burners for Firing Waste Fuels

WASTE by-products of oil refining, formerly difficult of disposal, are now burned in special plants to furnish electric and steam power. This is made possible by the design of high-capacity burners, some liberating 100,000,000 Btu. per hr. The author describes a wide-range mechanical atomizer of the circulating type and the results of an installation at the Louisiana Station of the Louisiana Steam Products, Inc., at Baton Rouge. The burners are successfully firing crude or lubricating (acid) sludge, soda bottoms, neutralized sludge,

acid tar, wax tailings, and flux bottoms, in addition to fuel oil. (Paper No. FSP-53-27, by R. C. Vroom.)

MACHINE SHOP PRACTICE

Machining Properties of Some Cold-Drawn Steels

THIS paper gives the results of a series of machining tests on 13-cold-drawn screw-stock steels and 2 cold-drawn stainless steels. Machinability values for standardized conditions are given for each steel as follows: The force required to remove a chip by a planer tool; the energy required to remove a chip by a single-tooth milling cutter; the torque and thrust developed by a $^3/_4$-in.-diameter drill; the penetration of a $^1/_4$-in.-diameter drill under a constant feeding load. An attempt is made to correlate the results of these various machining tests with the Brinell, Rockwell, and scleroscope hardness values, as well as the analysis and structure of each bar. Values representing the power required to cut 1 cu in. of metal per minute under specific standardized conditions are given for planing, milling, and drilling the various steels. (Paper No. MSP-53-6, by O. W. Boston.)

Mechanical Design of Electric Motors as Regards Standardization Interchangeability

THE electric motor has become a machine simply to do a job, and yet because it is vital and because the failure of a unit means its immediate replacement with a new one, there has been a growing need for uniformity in physical dimensions of units. The rapidity with which uses for electric motors are multiplying calls not only for the lowest possible cost of manufacture of what may be called the standard type, but also the many variations from this standard necessary to meet various conditions. This dictates uniformity also of the many accessory parts. (Paper No. MSP-53-7, by J. L. Brown.)

Flange Versus Foot-Mounted Motors

ADVANTAGES in favor of flange mounting given by the author include: improved appearance, compact arrangement, more rigid mounting, saving in weight, less cost, better alignment, more easy attachment, and better protection against oil, chips, and dirt. Full advantage cannot be taken of the benefits of flange mounting until some effort at standardization is made. Motor manufacturers can easily bring about such a standard to their own benefit and to the benefit of machine manufacturers generally, and the latter, it is believed, will readily accept such a standard. (Paper No. MSP-53-8, by Herbert Chase.)

Fundamentals of Machine Polishing

THE success of machine polishing depends on the proper coordination of the variables present in the work itself, in the polishing wheel, in the abrasive, in the machine, and in the glue used in setting up the polishing wheel. These variables are discussed in detail, and their relation to each other are set forth in this paper. Typical polishing machines are described, as well as examples of successful machine polishing. (Paper No. MSP-53-9, by Robert T. Kent.)

PETROLEUM MECHANICAL ENGINEERING

Lubrication of Textile Machinery

COTTON textiles require absolute cleanliness during manufacture and finishing, and all operations, including the lubrication of the equipment, are secondary to this requirement. Present designs incorporate modern developments which aid lubrication, and also provide a reserve supply of lubricant with ample protection to the fabric. Frequent application of minimum quantities of lubricant is accepted practice, but "freak" oils are not necessary. A list is included in the paper which indicates the frequency of application, cleaning period, and the product required. (Paper No. PME-53-1, by L. A. Baudoin.)

New Pipe-Still Design

METHODS and apparatus for applying heat to oil constitute the essential features of modern refinery practice. The tubular oil heater has developed rapidly, since adequate turbulence can be obtained in the tubes by high velocity and the surface can be arranged to give comparatively even distribution of heat.

The author describes a new design of still which does away with the conventional brick-lined combustion space and permits absorption of heat to begin immediately after its generation. This has led to an arrangement of heating surface where the flame from the burner is exposed directly to what may be considered as an excess of heating surface. With this arrangement the flame heats the tubes by radiance, and the tubes cool the flame. (Paper No. PME-53-2, by Luis de Florez.)

Use of Superheated Steam in Oil-Well Drilling

THE advent of deep drilling for oil has greatly increased the size of the equipment necessary for drilling. The cost of equipment has been mounting very much faster than the return from the wells. Furthermore, the transportation of this heavy equipment is becoming a serious problem. These factors have turned the oil industry to the engineer in its search for assistance in solving the problem of reducing the cost of drilling wells.

Conditions have become so serious that in spite of the fact that the driller pays nothing for his fuel, he is now able to buy power in some cases from public utilities, who pay for this same fuel, more economically than he can produce it. This condition has been brought about because little attention has been paid to decreasing the initial cost and increasing the life of the equipment. Utilities have overcome the fuel cost by more efficient design and operation of the power-plant equipment. The producing industry is in an excellent position to reduce the cost of drilling wells by taking advantage of the improvements that utilities and other industries have made in design of power equipment. By so doing they will recover the advantage of low or no fuel cost, and thereby reduce the cost of drilling. (Paper No. PME-53-3, by V. Weaver Smith.)

Lubrication Research Activities

A NEW general program for experimental work and publications recently formulated by the A.S.M.E. Special Research Committee on Lubrication is outlined in this, its fifth, report, and is followed by a brief statement of results already accomplished. Particular attention has been given to the coordination of data obtained by various investigators on viscosity under high pressure, to the study of pressure distribution in the oil film as applied to both thrust bearings and journal bearings, and to the development of methods for measuring oiliness. From experiments on the flow of liquids through very fine glass and platinum capillaries, it appears that the ordinary laws of viscosity may safely be relied upon down to a film thickness at least as small as one-millionth of an inch. The report concludes with a brief review of recent investigations. (Paper No. PME-53-4.)

WOOD INDUSTRIES

Improvements in Steels for Wood-Cutting Saws and Knives

THE important factors in a review of saw steels are the blade which carries the teeth and the teeth themselves. There is little in sight to promise further marked improvements in the solid-tooth type of saw. The next logical step is to use inserted teeth made from materials known to be well adapted to the function of cutting wood. The same forward step was taken years ago in metal cutting. (Paper No. WDI-53-5, by Henry B. Allen.)

Need of Forest-Products Engineers in the Woodworking Industries

FOR many years it was thought that a forester had to do only with the growing and handling of the forest crop. Now the forest schools recognize that the utilization of wood products, including the conditioning, remanufacturing, and merchandising of various forms, is just as important a part of forestry. To meet this situation, the curricula of some of the forest schools are changing. The woodworking industries have problems that need solution. Trained men who know about the technological features of wood are needed. In some way the forest schools have failed to train men to meet the demand in these wood-using industries. It is also felt that the industries have failed to cooperate with the schools in order to have the courses fit in with their needs. Closer relationship, however, is growing up between the industries and the forest schools. (Paper No. WDI-53-6, by Nelson C. Brown and Raymond J. Hoyle.)

Developments in the Stabilization of Painting Practice for Wood

PAINTING practice is changing from a craft to a part of engineering. The Forest Products Laboratory has tested the painting characteristics of softwoods. The tests included edge-grain and flat-grain boards, light wood consisting mostly of spring wood and heavy woods with wide bands of summer wood, white lead and prepared paint, various combinations of paint, linseed oil, thinner, and drier for the priming coat, and aluminum paint as a first coat. Conditions of dryness and of humidity entered into the tests. The basic factors responsible for the chief uncertainties of paint behavior were studied, and the way is pointed for a possible stabilization of painting practice for wood through further research. (Paper No. WDI-53-7, by F. L. Browne.)

Grading Timber for Strength

THIS paper deals with the development of grading rules for structural timbers, the principles involved, the effect of structural features on strength, and the application of the principles in commercial practice. Structural grading rules are based on the provisions of the American Lumber Standards, developed by the combined efforts of lumber producers, distributers, specifiers, and consumers, under the auspices of the U. S. Departments of Commerce and Agriculture. Structural material is divided into classes according to size and use.

The strength of wood members is influenced by the density of the wood, moisture, seasoning, and the size, location, and number of strength-influencing factors present, such as knots, shakes, checks, and slope of grain. Heartwood, sapwood, and wane are more important from other points of view than for their influence on strength. Principles of structural-material grading have been applied in a practical manner by lumber-manufacturers' associations in drawing up commercial grading rules.

Safe working stresses for various grades and different conditions of exposure have been established in accordance with strength of clear wood, effect of strength-influencing factors permitted, the effect of seasoning, time of loading, and the characteristics of each species. (Paper No. WDI-53-8, by Leyden N. Ericksen.)

NOTE: Those who have not registered in the A.S.M.E. Aeronautics, Applied Mechanics, Hydraulics, Fuels and Steam Power, Machine Shop Practice, Petroleum, and Wood Industries Divisions whose papers are abstracted on this and the previous pages, and who desire copies of any of these papers, may obtain them by using the form given below.

To THE SECRETARY, A.S.M.E., 29 West 39th Street, New York, N. Y. Date..........................

Please send copies of papers checked below:

Aeronautics	[AER-53-10]	[AER-53-11]	[AER-53-12]	[AER-53-13]		
Applied Mechanics	[APM-53-5]	[APM-53-6]	[APM-53-7]	[APM-53-8]		
Hydraulics	[HYD-53-1]	[HYD-53-2]	[HYD-53-3]	[HYD-53-4]		
Fuels and Steam Power	[FSP-53-17]	[FSP-53-18]	[FSP-53-19a]	[FSP-53-19b]	[FSP-53-20a]	[FSP-53-20b]
	[FSP-53-21]	[FSP-53-22]	[FSP-53-23]	[FSP-53-24]	[FSP-53-25]	[FSP-53-26a]
	[FSP-53-26b]	[FSP-53-27]				
Machine Shop Practice	[MSP-53-6]	[MSP-53-7]	[MSP-53-8]	[MSP-53-9]		
Petroleum	[PET-53-1]	[PET-53-2]	[PET-53-3]	[PET-53-4]		
Wood Industries	[WDI-53-5]	[WDI-53-6]	[WDI-53-7]	[WDI-53-8]		

PRINT name (Important)..

Street Address..City..........................

ENGINEERING STANDARDIZATION

Steps Forward

OCTOBER, November, and December have been productive months for the workers on the standards committees for which the A.S.M.E. is sponsor or joint sponsor. Fourteen of these committees held meetings in October, and twenty-two during November and December. These meetings were unusually well attended, and many important decisions were made which will advance the various projects many steps toward final approval by the American Standards Association. The most important of these actions are recorded below for the advance information of the readers of MECHANICAL ENGINEERING. Further details are available on application to the A.S.M.E. Standardization Committee.

Shafting and Keys. At two meetings held by this Committee during this period real progress was made toward completing the revision of the standard for shafting and stock keys. A series of large rectangular keys varying in width from $1^1/_2$ to 6 in. was developed and approved. These sizes, based on the same modified geometric series underlying the series of smaller keys already approved, are not related in the table to shaft diameter due to the great variation in design conditions in the large-shaft applications, but will constitute a choice of standard key sections from which the sizes required may be selected.

It had been proposed previously to include in this standard large-forged-shafting diameters from 6 to 20 in., but due to the special nature of the great majority of such shafts the Committee decided that such a table would be of little use. However, it was decided to extend the sizes of both transmission and machinery shafting from the present limit of 6 in. to include 8 in. diameter. The increments in size for both types and the point at which the transmission-shafting sizes should change from $^1/_{16}$ in. below the even half-inch and inch dimensions to the even dimensions will be the subject of a questionnaire to industry.

Steel Flanges and Flanged Fittings. A number of important items were approved at the meeting of the Subcommittee on this standard held on December 4, and it will now be possible to proceed toward republication of the American Standard for Steel Pipe Flanges and Flanged Fittings (B 16e). In accordance with the recommendations of the subgroups the following were approved in the form presented at the meeting and will be included in the revised pamphlet after approval by the A.S.A.: (1) Steel Flanged Fittings for 300 and 1500 lb steam pressure, (2) Companion Flanges for 150, 300, 400, 600, 900, and 1500 lb steam pressure, and (3) Steel Flanged Base Fittings for 300, 400, 600, and 900 lb steam pressure. The introductory notes will be revised where necessary to accommodate these additions.

Wrench-Head Bolts and Nuts and Wrench Openings. The American Standard for Wrench-Head Bolts and Nuts and Wrench Openings (B 18b-1927) was reviewed in detail at the meeting of the Subcommittee held on December 3, and a number of changes and additions were agreed upon as essential needs of the several industries involved. A few of the more important points covered by the Committee's actions are as follows: (1) addition of an American Standard Heavy Series of nuts and bolt heads in addition to the Regular Series at present known as the American Standard; (2) revision and extension up to $1^1/_2$-in. size of the American Standard Light and Castellated Nuts to coincide with present automotive practice; (3) inclusion of the $1^3/_8$-, $1^5/_8$-, and $1^7/_8$-in. sizes in both Regular and Heavy Series; and (4) provision for nine additional wrench sizes to provide for the addition of the Heavy Series and changes in the Light Series.

Small Tools and Machine-Tool Elements. Three new technical committees were added at the December meeting to those already organized by the Sectional Committee on the Standardization of Small Tools and Machine-Tool Elements. These are: Technical Committee No. 16 on Rotating Tool Shanks, E. J. Bryant, Chairman; Technical Committee No. 17 on Nomenclature for Small Tools and Machine-Tool Elements, Harry E. Harris, Chairman; and Technical Committee No. 18 on Multiple-Spindle-Drill Heads, the chairman of which is still to be appointed.

Rotating Air Cylinders and Adapters. At the Annual Meeting of the Sectional Committee on Small Tools and Machine-Tool Elements the final draft of the proposed American Standard for Rotating Air Cylinders and Adapters was discussed and released for approval by letter ballot of the Sectional Committee. This standard represents part of the work of the Technical Committee on Chucks and Chuck Jaws.

Punch and Die Holders. A proposal for an American Standard for Punch and Die Sets has just been completed by the Technical Committee on Punch and Die Holders, and it will shortly be ready for distribution to industry for criticism and comment. Preparatory to the drafting of this proposed standard the Committee issued two questionnaires and held several important meetings.

Lock Washers. A proposed American Standard for Lock Washers was completed and released by the Subcommittee on Lock Washers at its meeting held on October 21. General

NEW AMERICAN STANDARDS

The following standards were approved by the A.S.A. during the months of August 15 to December 15, 1931.

Drainage of Coal Mines (M6)

(American Recommended Practice.)

Sponsored by the American Mining Congress.

1931 Edition National Electrical Code (C1)

(American Standard.)

Sponsored by the National Fire Protection Association. Published by the National Board of Underwriters.

Rolled Threads for Screw Shells of Electric Sockets and Lamp Bases (C44)

(American Standard.)

Sponsored by The American Society of Mechanical Engineers and the National Electrical Manufacturers Association. Published by The American Society of Mechanical Engineers.

distribution of this proposed standard in printer's-proof form for criticism and comment is now in progress. In the course of development of the present proposal several preliminary drafts were prepared and thoroughly discussed at a number of meetings of the Subcommittee.

Charts for Lantern Slides. To meet the demand for the use of better lantern slides in the presentation of technical papers, the Subcommittee on Engineering and Scientific Graphs of the Sectional Committee on Standards for Graphic Presentation appointed a special subgroup to develop a brief brochure of good practice in the construction of charts which are to be reproduced as lantern slides. This material is now in printer's-proof form and was discussed at an open meeting of the Subcommittee held on December 3. Copies are available to those who are interested in this subject and willing to assist by giving criticism and comment.

Taper Pipe Threads. In September, 1931, a revised draft of the standard for Taper Pipe Threads was sent to the members of the Subcommittee. The latter accordingly discussed in detail at its meeting on December 4 the comments received from this distribution. The arrangement and contents were approved with editorial corrections and additions, the increased tolerances for working and reference gages having been accepted as proposed. In addition to the basic plug and ring gages contemplated by the present standard, the Subcommittee decided to include limit gages as an alternative type. These limit gages will be of the plug-and-ring type, with steps indicating the plus and minus one-turn tolerances as well as the basic size, and will be capable of being checked one against the other or against a basic gage. This proposed addition to the standard will be distributed shortly to the Subcommittee members for comment. The possibility of reducing the A.P.I. and American Standard thread lengths to a single series was reviewed again for the purpose of finding, if possible, a satisfactory basis for compromise with the American Petroleum Institute.

Speeds of Machinery. Through the activities of subcommittees the Sectional Committee on Speeds of Machinery completed last month its first tentative proposed series of standard speeds for driven machines and such driving units as electric motors. This proposal will soon be distributed to industry for criticism and comment.

Screw Threads for Hose Couplings. At its meeting on December 2 the Sectional Committee discussed the November, 1931, draft of the Proposed American Standard for Hose-Coupling Screw Threads in the light of the comments received from the distribution of the previous draft. The new draft was found generally satisfactory, although a rearrangement of Table 2, covering couplings for fire hose, garden hose, and other services, seemed advisable. This change together with other editorial changes and corrections will be included in a revised draft which will be distributed in the near future to the Committee members for further discussion.

Brass Plumbing Products. A proposed standard covering dimensions of faucets and connections has been released by the Subcommittee on Brass Plumbing Products for duplication and subsequent distribution. This proposal includes suggested standard dimensions of (*a*) handle screws, (*b*) seat washers or disk, (*c*) washer screws, (*d*) diameter of seat opening, (*e*) certain external diameters and lengths, (*f*) basin-faucet shank and tail piece, (*g*) bath-faucet shank, (*h*) offset bath supplies, and (*i*) hose connections. The proposals approved include also proposed dimensions of size of outlet opening in bath tubs, diameter of flange on spud and diameter of flange on waste ell, and height of bath-curtain rod from floor.

Two new Subgroups were appointed by this Subcommittee to undertake the standardization of (1) roughing-in dimensions of fixtures and (2) minimum requirements for brass alloy used in the manufacture of faucets, etc. Further study by the subgroups on Valves and Water-Works Brass prompted them to recommend that these items be dropped from the Committee's program for the present. The Subcommittee accepted these recommendations, and these two subgroups have been relieved from further activity.

Cold-Finished Steel Bars. The organization meeting of the Subcommittee on Cold-Finished Steels of the Sectional Committee on Stock Sizes, Shapes, and Lengths for Hot- and Cold-Finished Iron and Steel Bars was held on October 22. L. E. Creighton was elected chairman of the Subcommittee, and after the organization preliminaries were disposed of, the Subcommittee decided after full discussion to use the manufacturers' standard practice as the basis for its first proposals for shapes, dimensions, and tolerances.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Metal-Covered Airships

TO THE EDITOR:

The leading article in the August issue of MECHANICAL ENGINEERING, entitled "Some Recent Aspects of Rigid Airships," by Lieut. T. G. W. Settle, U. S. Navy, is of timely interest and comprehensive in its description of recent British and American airships which the author terms "derivative of the Zeppelin type of metal-structure, fabric-covered rigid airship."

Lieutenant Settle, who has been in charge of inspection during the construction of the new Navy airship ***Akron***, is well qualified through education and experience to write authoritatively on airships. Personal acquaintance with him impresses one with the fact that his primary interest in airships is genuinely scientific, and that he would not knowingly sponsor a statement which might be misinterpreted or leave a wrong impression with the layman. Consequently any criticism which follows should not be considered as a reflection either on Lieutenant Settle's judgment or his intentions, but rather as a comment on what might be termed "lack of precise definition."

The following paragraph is lifted out of the article in question for purposes of analysis.

> Laymen usually ask, "Why not use metal covering?" The answer is that metal is far too heavy, too weak against tearing, lacks resiliency, is not durable enough (corrosion), and is too difficult to install, maintain, and repair. However, the future may see certain limited areas of an airship's surface covered with metal.

At first glance it might be interpreted as a condemnation per se of the Metalclad type of airship, but evidently this is not

the intention, as is indicated by the following reference which appears near the beginning of Lieutenant Settle's article:

> The author will confine himself to a consideration of the Zeppelin type of metal-structure, fabric-covered rigid airship, and its British and American derivatives. The so-called "metalclad" airship, a metal-covered pressure type, is a most interesting development, but has not yet been built in a moderate or large size, and differs in fundamental operating characteristics from the Zeppelin type in that internal gas pressure is necessarily maintained in order that the hull may carry the aerodynamic loads imposed at all but low air speeds. By the term "airship" in what follows is meant the large, rigid [Zeppelin type[1]] airship.

Applying this precise qualification, it is apparent that Lieutenant Settle intended to limit his article to a discussion of contemporary and future Zeppelin ships, in which case his discouraging comment on the use of metal as a covering for airships should be interpreted as applying to the conventional Zeppelin only, and not holding true with respect to the Metalclad, which is an entirely different engineering structure.

Finally, it is submitted that the art of airship development is too young to permit preconceived ideas and unalterable opinions to prejudice one's judgment and limit one's range of investigation. The designers and builders of both fabric-covered and metal-covered airships will each make their contribution to the super-airship of the future, which will be capable of successful commercial operation. Each school of design has much to learn both from contemporary development and from such application of materials as future experience may disclose to be sound practice.

"What is not yet, may be."

CARL B. FRITSCHE.[2]

Detroit, Mich.

Up-Flow vs. Level-Flow Die-Casting Machines

TO THE EDITOR:

Die-casting machines for lower-melting-point-alloy castings may be classified into three systems: down-flow, up-flow, and level-flow machines, according to the direction in which the metal enters the die. As the down-flow type has been discarded as obsolete, the two remaining systems are the only ones to be found in operation. Their chief distinction is that their closing dies and goosenecks move simultaneously in a vertical plane in the case of the up-flow type, and in a horizontal plane in the case of the level-flow type.

Though die-casting machines are a comparatively recent invention a fairly large number of models of the two systems are on the market. When comparing the efficiencies of die-casting and metal-working machines, the former will be found to be characterized by the necessity for frequent repairs, replacements, general breakdowns, and by the high percentage of castings which have to be relegated to the junk pile. This, however, merely indicates that die-casting machines have but recently emerged from the experimental stage. Their evolution and gradual perfection are bound to result in a precision and efficiency not at present anticipated.

Improvement will eventually be accomplished by concentrating the designer's inventive genius upon the solution of the most desirable features, and, to begin with, he can simplify his task by deciding whether the up-flow or level-flow machine is the better, and specializing upon machines of the chosen type. The facts upon which this decision should be based, as deduced from actual experience and shop requirements, are discussed in what follows.

The problems involved in the discussion are those which contribute mostly toward the inefficiency of the machine and they may be itemized as follows in the order of their respective importance: (1) Installation of moving or closing die; (2) replacement of worn-out nozzle; (3) gooseneck alignment; (4) elimination of splashing; and (5) installation of fixed or bolster die.

The moving or closing die usually consists of two or three parts (die form, ejector-pin plate, bolster plate) aggregating in weight from 50 to 150 lb according to type and size of casting. This composite die after having been assembled on the bench, must be hoisted into place by an overhead chain-and-tackle arrangement, lined up with respect to the fixed die, and fastened by holding devices. Experience has taught that such an installation is a difficult and dreaded piece of work in the case of level-flow machines. Even with modern hoisting and appropriate fastening systems 20 to 30 minutes are consumed before the machine is ready for operation. The difficult line-up and the poor accessibility of the bottom fastening strap are the most objectionable handicaps.

The removal and subsequent installation of the die is an unwelcome but rather frequent necessity in the case of castings with numerous pin holes, since the breaking off of the pin points requires the removal of the die for repair. Consequently many operating hours are lost, the repair requiring less time than the mounting and dismounting of the die.

Doubtless the vertical arrangement of the up-flow machine will shorten this job considerably as the line-up will be much simpler and the fastening clamps are all easily accessible.

No decided advantage can be ascribed to either of the two systems in so far as the replacement of a worn-out nozzle is concerned, as the different steps are identical.

The speed of the alignment of the gooseneck depends upon the mechanical arrangement available, as well as upon the distance which the nozzle has to travel from its starting point to the gate bushing. A short distance is conducive to a quicker alignment and, incidentally, to a casting of higher grade. Consequently the advantage lies with the vertical system, where the metal pot is underneath the gate bushing and the gooseneck travels in but one direction—straight upward, in contrast to the horizontal system, in which the gooseneck movements are either a circular or a combined upward and forward motion. The swinging or circular arrangement has been found rather unsatisfactory in practice with regard to an accurate and lasting line-up. This flaw is not so conspicuous with the upward-forward type, whose chief defect may be found in its long travel. It has been assumed in this discussion that the mechanical arrangements controlling the line-up in the two types are of equal merit. Nevertheless, ignoring none of the vulnerable points of die-casting machines, it is believed that there is a fair possibility of enhancing the advantage of the up-flow type by designing a line-up arrangement which will be superior to that of the latest level-flow machines.

Splashing is one of the nuisances of die-casting machines which cannot be entirely avoided irrespective of the operator's carefulness. It is caused by small leaks between the gate bushing and nozzle, and increases with the number of shots made per hour. If not chipped away at certain intervals, the solidified metal will accumulate and impede the free movement of the gooseneck with the attached nozzle. Much annoyance and loss of time from that quarter can be prevented by using a properly designed vertical die-casting machine, since the metal

[1] Words in brackets inserted by writer.

[2] President, Aircraft Development Corporation, builders of the Metalclad ZMC-2 for the U. S. Navy. Mem. A.S.M.E.

spray caused by the splashing will mostly fall back into the pot, either by gravitation or by reason of the propelling force applied to the molten metal. No redeeming feature in this regard is offered by the level-flow die-casting machine.

The fixed or bolster die is usually equipped with hydraulically operated cores (and is sometimes called a core die), and its removal becomes necessary with signs of a defective core mechanism. Both removal and installation are difficult, especially in the case of heavy dies. Generally speaking, the same principles apply as those outlined for moving dies. Again the disadvantage of the level-flow machines is the necessity of holding the die (sometimes weighing around 200 lb) in place by some makeshift arrangement, until the fastening clamps have the die amply secured.

For the reasons given it seems obvious that the up-flow or vertical die-casting machine is preferable to the level-flow type from the point of view of operation and maintenance. In spite of the fact that the level-flow machines predominate in the market, their efficiency and merit may be questioned whenever large and complicated castings are involved. And even in case of smaller castings their superiority is doubtful, since the design of a vertical die-casting machine, embodying the good features of a level-flow machine but eliminating or minimizing its disadvantages, is feasible and presents no insurmountable problems.

ERNST SEIDEWITZ.[3]

Chicago, Ill.

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 680 (Reopened), and 694 to 698, as formulated at the meeting on October 23, 1931, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE No. 680 (Reopened)

Inquiry: Will a steam-gage siphon which is formed to provide a water pocket between baffles in the body of the device, meet the requirements of the Code for Low-Pressure Heating Boilers if it is made of ferrous metal, if its water capacity is not sufficient to insure that the gage tube will be kept full of water under all conditions of normal operation, if the connection between it and the steam gage is of 1/4-in. ferrous pipe, if the minimum area through the siphon is less than the equivalent of 1/2-in. pipe size, and if it is installed so that the water pocket is immersed in the steam space of the boiler?

Reply: The fact that the siphon is made from ferrous metal does not, in the opinion of the Committee, violate the requirements of Pars. H-55 and H-108. The siphon as described does not meet the requirements of Pars. H-55 and H-108 if the water capacity is not sufficient to keep the gage tube filled with water under all conditions of normal operation, nor unless all parts of the piping less than 1/2-in. pipe size are of brass, copper, or bronze composition. It was not the intent of the Code to prohibit the use of a ferrous siphon of the type described with an area less than the equivalent of 1/2-in. pipe size, nor to sanction the installation of a siphon with the water pocket immersed in the steam space of the boiler. A revision to incorporate the details covered by this interpretation is under consideration.

CASE No. 694

(In the hands of the Committee)

CASE No. 695

Inquiry: When attaching to a dished head a cast or forged steel nozzle which exceeds 6 in. in any dimension, is it necessary to increase the thickness of the head by 1/8 in. over that required for a blank unstayed dished head, provided the nozzle is properly reinforced as is required if the nozzle were placed in the shell? It is noted that under Par. U-36 no increase in thickness is necessary if the nozzle is placed on an elliptical head, but no mention is made whether or not this rule would also apply to a head that is dished to a segment of a sphere.

Reply: It is the opinion of the Committee that when a cast or forged steel nozzle is attached to a head dished to a segment of a sphere and is properly reinforced in accordance with the rules referred to in Par. U-59, no increase of thickness over that required for a blank unstayed dished head need be made.

CASE No. 696

Inquiry: Would it be permissible to use plate of less thickness than 1/4 in. in the fabrication of hot-water heaters of 24 in. or less in diameter, carrying a pressure of 100 lb or less, as specified in Par. H-12 of the Code?

Reply: It is the opinion of the Committee that for such construction the minimum plate thickness is 1/4 in. as specified in Par. H-12.

CASE No. 697

Inquiry: Is it the intent of Par. U-73c of the Code that dished heads inserted into shells as shown in Figs. U-15b or U-15c are permitted only in Class 3 vessels?

Reply: It is the opinion of the Committee that inserted heads as shown in Figs. U-15b and U-15c of the Code can be used only in Class 3 vessels.

CASE No. 698

Inquiry: In using Table P-11 of the Code to determine the minimum size of boiler outlets for safety-valve connections on firebox boilers, is it permissible to interpolate between the values given therein for intermediate pressures, or shall relieving capacity for the next lower or next high pressure be used?

Reply: The discharge capacities given in Table P-11 may be interpolated to determine the values for intermediate pressures.

[3] Engineer, 4022 Belle Plaine Avenue.

INSTRUMENTS AND APPARATUS

Preliminary Draft of Part 21—Leakage Measurement; Chapter 2 on Boiler, Piping, and Engine Leakage

The Main Committee on Power Test Codes takes pleasure in presenting to the members of the Society for criticism and comment, Part 21—Leakage Measurement; Chapter 2 on Boiler, Piping, and Engine Leakage. The Individual Committee which has developed this draft consists of Messrs. C. F. Hirshfeld, Chairman, W. A. Carter, Secretary, C. M. Allen, E. G. Bailey, L. J. Briggs, C. R. Cary, J. D. Davis, R. E. Dillon, F. M. Farmer, J. B. Grumbein, W. H. Kenerson, E. S. Lee, E. L. Lindseth, O. Monnett, S. A. Moss, R. J. S. Pigott, E. B. Ricketts, and W. A. Sloan.

The "Instruments and Apparatus" Section will consist of twenty-one parts dealing with: (1) General Considerations,[1] (2) Pressure Measurement (6 chapters),[2] (3) Temperature Measurement (9 chapters),[3] (4) Head Measurement, (5) Measurement of Quantity of Material, (6) Electrical Measurements, (7) Mechanical Power, (8) Measurement of Indicated Horsepower, (9) Heat of Combustion, (10) Flue-Gas Analysis, (11) Determination of Quality of Steam,[4] (12) Time Measurements, (13) Speed Measurements,[5] (14) Mechanical Measurements, (15) Surface Area, (16) Density Determinations,[6] (17) Determination of Viscosity of Liquids,[7] (18) Humidity, (19) Concentration of Dilute Solutions, (20) Smoke-Density Determinations, and (21) Leakage Measurements (2 chapters).[8]

Complete copies of the draft, which is published here in abstract, may be obtained from the Society's headquarters. The Individual Committee, the Main Committee, and the Society will welcome suggestions for corrections or additions to this draft from those who are especially interested in this subject. These comments should be addressed to the Chairman of the Committee, in care of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

CONTENTS

SECTION I—BOILER AND PIPING LEAKAGE

General

1 *Boiler or Piping Leakage* or both are a potential source of error in every power-plant equipment test which involves the weighing or measuring of water or steam. Hence it is necessary that this source of error be either eliminated, reduced to an amount which to the satisfaction of all parties concerned may be ignored, or measured and accounted for.

2 In general, the safest method of dealing with leaks is to stop them. This requires, first of all, that all visible leaks which may affect the test be eliminated. Further, there shall be no leakage to or from piping connecting with the test piping and apparatus. This includes leaks through side connections, blow-off lines, safety valves, relief valves, whistles, heaters, drains from traps and separators, etc. All side connections shall be blanked off unless absolute assurance may otherwise be had that no water or steam can enter or leave the test piping through these connections. Where a side connection is closed off by two valves in tandem with a telltale drain between them, or by a double-seated straightway valve with a telltale drain in the bottom of the valve body between the seats, assurance of the tightness of the valves may be had if no water or steam appears at the open telltale. Since the appearance of water or steam at a telltale may indicate leakage of either or both valves, it is essential that no visible leakage through the telltale be permitted. If there is an open drip attached at the low point of an unused or empty section of pipe beyond a valve, the fact that no water or steam escapes here is evidence of the tightness of the valve.

3 In the event that boiler and piping leakage which may affect a power-plant equipment test can be neither eliminated nor made small enough so that with due regard to the possible influence on test results and to the accuracy desired it may be ignored, the leakage shall be determined quantitatively by the methods described in Pars. 4 to 9, inclusive.

Test Determination of the Amount of Boiler and Steam-Piping Leakage

4 Where it is necessary to determine the amount of leakage from a boiler and from the superheater, steam piping, etc., between the boiler and a certain point, such as the throttle valve of a prime mover or the stop valve at the superheater outlet, a boiler-water-gage-glass test shall be performed. This test consists, in general, of a determination of the total amount of water and steam leaving the boiler during a measured period of time and a simultaneous determination of the amount of steam condensing in the piping, superheater, etc. The boiler and steam-piping leakage is then equal to the total amount of water and steam which left the boiler, minus the condensation. The test procedure is outlined in Pars. 5 to 7, inclusive. Leakage determination as made by the boiler-water-gage-glass method are subject to error, due principally to the relatively

[1] See pamphlet published in June, 1928.

[2] Chapter 1 of Part 2, on "Barometers," was published in pamphlet form in June, 1929. Chapter 6 of Part 2, on "Tables, Multipliers, and Standards for Barometers, Mercury and Water Columns, and Pressure Measurements," was published in pamphlet form in June, 1929.

[3] Part 3, Chapter 1, "General," Chapter 5 on "Pyrometric Cones," Chapter 6 on "Liquid-in-Glass Thermometers," and Chapter 7 on "Bourdon Tube Thermometers," were published in pamphlet form in March, 1931.

[4] See pamphlet published in January, 1931.

[5] See pamphlet published in December, 1930.

[6] See pamphlet published in April, 1931.

[7] See pamphlet published in January, 1931.

[8] Chapter 1 of Part 21, on "Condenser Leakage Tests," was published in pamphlet form in November, 1928.

large effect on the test results of small inaccuracies in the boiler-water-level measurement and to the different steam conditions prevailing during the leakage test as compared with those during normal operation. The effect of inaccuracies of boiler-water-level measurement, which is present also in all tests involving the weighing or measuring of boiler feedwater, may be minimized by extending the duration of the leakage test. Leakage determinations as made by the boiler-water-gage-glass method have a tendency to indicate a higher rate of leakage than that obtaining during normal operation, due to the fact that the steam in the superheater and steam piping during a leakage test is generally at a lower superheat or quality than during normal operation; hence, a greater rate of discharge occurs through a given-sized opening. Therefore, if a leakage test shows that a correction of considerable magnitude must be introduced in a subsequent test, the possibility of error in this correction shall be recognized and all possible steps shall be taken to reduce the leakage.

5 *Determination of the Total Amount of Water and Steam Leaving the Boiler.* The measurement of the total amount of water and steam leaving the boiler during a leakage test is dependent upon readings of the water level in the boiler gage glass, or glasses, at the start and at the conclusion of the test, and it is assumed that the water level in the boiler is the same as that in the glass. If the gage glass is to give a true indication of the water level in the boiler, the water in the glass shall be of the same density as the water in the boiler, hence it must be at the same temperature as the boiler water. (In this discussion any effect of steam bubbles on the density of boiler water is ignored since during a leakage test the boiler is operating at any extremely low rate of driving.) The only time that the water in the gage glass is at boiler-water temperature is immediately after the water column has been blown down. Therefore, to obtain accurate boiler-water-level readings it is necessary to blow down the water column immediately before the water level is recorded at the start and at the conclusion of the test. The water blown down before the recording of the final water-level reading shall be measured and its amount later deducted from the total quantity of water and steam leaving the boiler during the test. When the precaution of blowing down the water column immediately before recording boiler-water-level is not observed, the height of the water in the gage glass may differ from that in the boiler by five per cent or more of the height above the lower water-column connection, with a corresponding error in the measurement of the amount of water and steam leaving the boiler. If it is decided that the accuracy desired does not warrant the refinement of blowing down the water column before water-level readings are taken, the water column shall not be blown down during the leakage test, nor for a period of at least two hours before the start of the test. The recommended procedure for determining the amount of water and steam leaving the boiler during the leakage test is as follows:

(*a*) A scale must be rigidly mounted on the gage glass.

(*b*) For the cooling, collection, and measurement of the water blown down from the water column, the blowdown pipe shall discharge either to a small surface condenser or into an open barrel, the pipe extending nearly to the bottom of the barrel, which is initially three-quarters full of cold water. The condensate from the small condenser shall be weighed for the determination of the amount of water blown down. A measurement of the amount of blowdown by cooling and collection in a barrel consists of weighing the barrel of water before and after the blowdown is introduced and subtracting the initial weight from the final weight.

(*c*) The point in the steam piping (such as the throttle valve of a prime mover) up to which the boiler and steam-piping leakage is to be measured shall be closed off and known to be tight (see Par. 2.)

(*d*) All side connections to the steam line that cannot be blanked off or otherwise made to comply with the requirements of Par. 2 must be shut off as tightly as possible. If the object of the leakage test is to determine the correction to be applied to the amount of boiler feedwater in the calculation of the quantity of steam delivered to a certain point (such as the throttle valve of a prime mover) during a subsequent steam-consumption test, a small amount of leakage to side connections will cause no error in the steam-consumption test provided this leakage is the same during the leakage test as during the steam-consumption test. Hence it is important that the pressure in the side connections beyond the closed valves be the same during the leakage test as during the steam-consumption test, and that the valves be neither opened nor altered in any way between the two tests.

(*e*) Boiler blow-off valves shall be shut and known to be tight (see Par. 2).

(*f*) The boiler-water level shall be raised to a point near the top of the gage glass.

(*g*) All boiler-feed valves shall be closed and known to be tight (see Par. 2).

(*h*) Boiler pressure shall be maintained within the working range. This may be done by means of a very slow fire in the case of hand- and stoker-fired boilers, or by intermittent operation of burners in the case of pulverized-fuel-, gas-, and oil-fired boilers.

(*i*) Sufficient time shall be allowed to elapse for the pressure and rate of fall of water level to become constant. From fifteen minutes to several hours may be required, depending upon the amount of brickwork in the setting, the temperature of the brickwork prior to the starting of the test, and the expertness with which the boiler is fired.

(*j*) After the steam pressure and the rate of fall of water level have become constant, the water column shall be blown down thoroughly, the blowdown water being wasted. The blowdown valve should then be closed tightly.

(*k*) One-quarter of a minute after the water-column blowdown valve has been shut off, the water level in the gage glass and the time shall be recorded.

(*l*) The steam pressure shall be maintained constant for two hours or more, the duration of the test depending upon the accuracy desired.

(*m*) At the expiration of the allotted time the water column shall be blown down, discharging into the small condenser or barrel of cold water for measurement. The water column shall be blown down at a rate great enough to cause the water to entirely leave the gage glass. It is necessary that the cooling capacity of the small condenser or barrel of cold water be sufficient to permit this without escape of steam. After at least fifty pounds of water have been collected, the blowdown valve shall be tightly closed. The amount of water blown down shall be recorded.

(*n*) One-quarter of a minute after the closing of the water-column blowdown valve, the water level in the boiler-gage glass shall be recorded.

(*o*) The total volume of water and steam which leaked from the boiler or was evaporated during the leakage test shall be calculated from the drop in water level. The

particular method of calculation varies for different types of boilers. For example, in the case of a horizontal drum, the cross-sectional area of the layer of water which disappeared may be determined from a formula or table for the areas of segments of circles and multiplied by the length of the drum. For an inclined drum the average free water surface during the leakage test, determined with the aid of a formula or table for the areas of ellipses or segments of ellipses, may be multiplied by the drop in water level. Allowances shall be made for dished heads and boiler tubes at the liberating surface.

(*p*) The total weight of water and steam which left the boiler during the leakage test shall be calculated by the following equation:

$$V = W(d_f - d_g)$$

in which

W = weight of water and steam which left the boiler during the test period, pounds

V = volume of water which leaked from the boiler or was evaporated during the test period, cubic feet. [As calculated in (*o*)].

d_f = density of water at the temperature of saturated steam at the observed boiler pressure, pounds per cubic foot

d_g = density of dry, saturated steam at the observed boiler pressure, pounds per cubic foot.

6 *Determination of the Amount of Condensation Collecting in Steam Piping, Superheater, Separator, Etc.* The condensation collecting in the steam piping, superheater, separator, etc. during the leakage test shall be drained from the piping, cooled to prevent flashing, and collected for measurement. The procedure is as follows:

(*a*) A drip line from each point where condensation collects in the superheater, steam piping, etc. shall discharge through a receiver (such as a float or bucket trap) which is equipped with a gage glass and with a tight valve at its outlet, into a small surface condenser or a barrel of cold water for the cooling, collection, and measurement of condensation by the same method as outlined for water-column blowdown in Par. 5, Item (*b*). It is permissible to pass condensation from several points into a single condenser or barrel.

(*b*) Simultaneously with the start of the measurement of the amount of water and steam leaving the boiler [Par. 5, Item (*k*)], the discharge valve of each receiver shall be opened until the water level is visible in the gage glass. The discharge valve shall then be closed tightly and the water level in each gage glass marked. Water drained from the piping at this time should be wasted.

(*c*) Periodically during the progress of the test, the valve at the discharge of each receiver shall be opened, allowing the accumulated condensation to pass into the condenser or barrel for collection, until the water level in the receiver has been lowered to the marker, in order to prevent the steam line from becoming flooded.

(*d*) Simultaneously with the reading of the final boiler water level [Par. 5, Item (*n*)], the condensation shall be drained from each receiver until the water level is lowered to the marker.

(*e*) The total weight of condensation drained from all the receivers during the test shall be determined.

7 *Calculation of the Amount of Boiler and Steam-Piping Leakage.* The amount of boiler and steam-piping leakage occurring during the test is equal to the pounds of water and steam leaving the boiler [the quantity W in Par. 5, Item (*p*)]; minus the pounds of water blown down from the water column preliminary to the reading of the final boiler water level [Par. 5, Item (*m*)]; minus the pounds of condensation drained from the piping, superheater, separator, etc. [Par. 6, Item (*e*)].

TEST DETERMINATION OF THE AMOUNT OF LEAKAGE FROM FEEDWATER PIPING

8 If the precautions against leakage which are described in Par. 2 cannot be followed in regard to feedwater piping where feedwater is to be weighed or measured, it is necessary to test the tightness of the feedwater piping. All side connections to the feedwater piping that cannot be blanked off or otherwise made to conform to the requirements of Par. 2 shall be closed off as tightly as possible. Boiler-feed valves shall be closed and known to be tight (see Par. 2). The boiler-feedwater pressure shall be maintained at its normal value by operation of the feed pump. Leakage is then measured by the loss of water from the supply tank. If the object of the test is to determine the correction to be applied to the amount of water measured in the supply tank during a subsequent test to determine the quantity of water fed to the boiler, a small amount of leakage to side connections will introduce no error in the latter test provided this amount is the same during both tests. Hence, the pressure in the side connections beyond the closed valves shall be the same during the leakage test as during the feedwater-measurement test, and the valves shall not be opened, tightened, nor altered in any way between the two tests. In the case of a centrifugal boiler-feed pump, excessive heating of the pump may occur during the leakage test due to the very small amount of water flowing through the pump. To prevent this heating, a continuous flow through the pump shall be provided by allowing water from the discharge piping or from the priming connection on the last stage of the pump to return to the supply tank.

TEST DETERMINATION OF THE AMOUNT OF LEAKAGE FROM CONDENSATE PIPING

9 Where it is necessary to determine the amount of leakage from condensate piping between the hotwell pump of a surface condenser and the condensate weighing tanks, the test procedure is similar to that followed for the determination of the amount of leakage from feedwater piping (Par. 8). With the condensate discharge to the weighing tanks closed off and the pressure in the piping maintained at its normal value by operation of the condensate pump, leakage is revealed by the drop of the water level in the condenser hotwell.

SECTION II—ENGINE LEAKAGE

10 Test determinations of the amount of steam engine leakage provide a basis for the judgment of the mechanical condition of engines by detecting and, in some cases, locating serious leaks of pistons, valves, etc. The data from a leakage test, although having no place in the calculation of a steam-consumption test of an engine, supply information which may aid in the analysis of the results of the latter test.

11 Of necessity, any test to determine the amount of valve and piston leakage which may be conducted with ordinary facilities is made while the engine is at rest. The result of such a test is a measure of the "static leakage" of an engine but cannot be considered an accurate representation of the amount of leakage occurring during actual operation, when the parts are in motion, the pressure differentials causing leakage are continually changing, and the conditions of lubrication are different.

THE A.S.M.E. ANNUAL MEETING

Impressive Gathering Characterized by Discussion of Economic Subjects—Secretary Rice Honored—Significant Technical Sessions

ECONOMICS shared the honors with engineering as a subject of major interest at the fifty-second annual meeting of The American Society of Mechanical Engineers, held in New York, November 30 to December 4, 1931. As was expected, the registration, approximately 2000, fell somewhat behind last year's 2500. There was no falling off in interest and significance, however, nor in the extent of the program. Rough statistics indicate that there were scheduled 25 technical sessions, 72 committee meetings, and 80 technical papers and reports, in addition to 6 special lectures and numerous other activities of a social and professional nature.

HONORARY MEMBERSHIPS AND AWARDS

A unique feature of this year's meeting was the conferring of honorary membership upon Calvin W. Rice, for twenty-five years secretary of the A.S.M.E. No event in many years has met with such enthusiastic approval of members of the Society and engineers generally in this country and abroad. Elsewhere in this issue will be found the address delivered at the Annual Dinner by Dr. Karl T. Compton, president of M.I.T., in which Dr. Rice's professional record is set forth and an analysis is made of the services which he has rendered to the development of professional engineering societies and the philosophy of their organization and administration.

No more appropriate time exists than an annual meeting for honoring members whose services and attainments have brought them distinction and recognition. Dr. Palmer C. Ricketts, president of Rensselaer Polytechnic Institute, was made an honorary member of the A.S.M.E. at a delightful "Presidents' Night" function on Tuesday evening, "in recognition of his contributions to engineering education." On this same occasion numerous other awards and medals were conferred. The A.S.M.E. Gold Medal was conferred upon Albert T. Kingsbury, "in recognition of his research and development work in the field of lubrication." On Arthur E. Grunert was conferred the Melville Award for his paper on "Comparative Performance of a Pulverized-Coal-Fired Boiler Using Bin System and Unit System of Firing."

The Junior Award for 1931 went to M. K. Drewry for his paper on "Radiant-Superheater Developments." The Charles T. Main Award for 1931 was given to Robert Elmer Klise for his paper on "Interchangeability—Its Development and Significance in Industry."

Jules Podnossoff received the Student Award for 1931 for his paper on "Pressure and Energy Distribution in Multi-Stage Steam Turbines Operating Under Varying Conditions."

Three members of the A.S.M.E. were presented with the John Scott Medals by the Board of Directors of City Trusts of Philadelphia. They were Albert H. Emery, Jr., honored "for the invention of the Southwark-Emery testing machine;" Willis H. Carrier, "for the invention of process and apparatus for cleaning, purifying, and humidifying the air;" and Albert Kingsbury "for the invention of a thrust bearing for use in ships and heavy machinery."

A VARIED PROGRAM

An A.S.M.E. Annual Meeting is a many-sided affair, planned with great care to make the week in which it is held yield the greatest amount of benefit not only to those who are able to attend, but also to absent members and the engineering profession as a whole. Advantage is taken of the presence in New York of hundreds of committee members to call meetings of groups that may not find so convenient an opportunity at any other time, to report on the past year's accomplishments

RETIRING PRESIDENT ROY V. WRIGHT CONGRATULATING CONRAD N. LAUER ON HIS ACCESSION TO THE PRESIDENCY

PRESIDENT WRIGHT CONFERRING HONORARY MEMBERSHIP IN THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS ON DR. RICE

and plan for the future, to lay out programs for the Professional Divisions, and to discuss important questions of internal policy with the delegates of the Local Sections.

The technical events of the Annual Meeting, which form the nucleus around which a varied program is built, demand simultaneous sessions, as many as four being held morning and afternoon, and coinciding also with the meetings of the numerous committees. Personal programs require careful study in filling them out in order that the cream of the meeting, as every member sees it, may be skimmed off first. What with research conferences, symposia that clarify existing conditions and point out trends, cooperative sessions with sister societies, and the Professional Divisions' technical sessions, the time is all too short.

GENERAL LECTURES

A cross-section of the A.S.M.E. is represented by those attending an annual meeting. To appeal to their common interests—those that lie outside the fields of technology in which each member has a personal interest—general lectures and social and non-technical events are provided, introducing a stimulating and broadening influence into the proceedings. Repeating a most successful experiment inaugurated last year, Dr. S. Marion Tucker, of Brooklyn Polytechnic Institute, gave three brief addresses on Tuesday, Wednesday, and Thursday mornings on "Talking With an Audience." These addresses were followed by conferences in which Dr. Tucker discussed problems involved in speaking before an audience with those seeking personal help and advice. Judging from the large and enthusiastic audiences, and the interest displayed in the conferences, Dr. Tucker's common-sense theories and advice were equally well appreciated this year.

One of the encouraging signs of the times is the increasing interest that engineers, individually and as a profession, show in subjects outside their technological specialties. Favorable comment on historical articles that have appeared from time to time in MECHANICAL ENGINEERING was heard, and there was some talk of the formation of a Professional Division devoted to the study of the history of engineering. More significant, however, is the quickening of interest in economics.

TOWNE LECTURE ON ECONOMICS AND ENGINEERING

Back in 1886, when the A.S.M.E. was but newly formed, Henry Robinson Towne delivered an address on "The Engineer as an Economist," in which he developed this vital subject. To perpetuate Mr. Towne's memory, and to foster the engineers' interest in this important interrelation of the physical and social sciences, the A.S.M.E. established the Henry Robinson Towne lectures. The fourth Towne Lecture was delivered this year by Wallace B. Donham, dean, Graduate School of Business Administration, Harvard University, and author of a recent book entitled "Business Adrift." The title of Dean Donham's address was "Twenty-Year Plans as Related to the Temporary Emergency." The complete text of the address is printed elsewhere in this issue, hence no attempt to summarize it will be made here. The address deals with fundamental aspects of capitalistic economics. In an analogy to organic evolution, Dean Donham showed that there had been built up in man a permanent adaptation to persistent changes in environment, a subconscious ability at insulation and defense, numerous compensating mechanisms, and an ability to make rational decisions. A social organism faces problems similar to those that confront physical organisms, and it was Dean Donham's belief that we could learn much from this biological analogy.

STABILIZATION SYMPOSIUM

Dean Donham's thought-provoking address was followed up on Wednesday morning by a symposium of three papers on stabilization presented under the auspices of the A.S.M.E. Management Division with the cooperation of the American Management Association. The session was an outgrowth of a similar symposium held last year. It was presided over by Ralph E. Flanders, whose "debate" with Dr. Wesley C. Mitchell on the engineer's and the economist's points of view was a feature of the 1930 Annual Meeting. This year the financial, industrial, and economic phases of business stabilization were discussed by Paul M. Mazur, James W. Hook, and Virgil Jordan. Seldom has so intensely interesting a symposium been conducted by the A.S.M.E. Of the three papers, that by Virgil Jordan, economist, McGraw-Hill Publishing Co.,

New York, appears in full in this issue of MECHANICAL ENGINEERING. It is hoped that adequate publication of the other papers can be provided in the near future.

AS A BANKER VIEWS STABILIZATION

Paul M. Mazur, partner, Lehman Bros., New York, whose book, "New Roads to Prosperity," has recently appeared, spoke first and presented the financial point of view. Speaking extemporaneously and without notes, Mr. Mazur gave what was perhaps the first presentation of the financial side of the stabilization problem before an A.S.M.E. meeting. His subject was "Some Thoughts on the Solution of the Depression Problem." His development of it took the form of an attempt to answer the question, "What will President Hoover say to Congress?"

After contrasting the exact nature of science with the inexact nature of economics, Mr. Mazur suggested that President Hoover, in his message to Congress, would consider the dole, which would receive the official frown and which the President would hope would prove unnecessary in this country; the railroads; the banks; modification of the Federal Reserve Banking System; and a suggested mortgage bank, which, in his opinion, was destined to failure if it merely transferred a bad asset from one place to another, because those whose debts would thus be liquidated would not be likely to enter further ventures in building. Thus despite the fact that there is a $3^1/_2$ billion deficit in home building, and while building is essential to stabilization, there is no guarantee that the Hoover plan will stimulate building.

DR. PALMER C. RICKETTS, HONORARY MEMBER, A.S.M.E.

Mr. Mazur explained the gold standard of currency and showed that credit for investment depends on the well-being of trade, on the supply of gold, and on faith. Prices at present are too low. During the past fifteen years, he said, industry had rebuilt itself while prices were falling, and faced now an indebtedness one-third greater, because of the price level, and hence the prospects of no profits or insolvency. Thus, with funded obligations still in existence, business was finding itself throttled by the money factor. Inasmuch as no means existed at present for controlling the money level, we could not look to credit to stimulate business. However, it might be possible, he thought, to develop building as a synthetic stimulus to business.

Turning to a consideration of a repetition of the present depression, Mr. Mazur alluded to the suggestion frequently heard of a general economic staff for planning purposes. He pointed out the dangers inherent in governmental interference with business. Our capitalistic system, he said, was based on the theory of an intense individualism, but, he went on to say, this was not a strictly individualistic age. Collectivism might still step in, should conditions become favorable. Thus he was in favor of a general economic staff if it could provide information accurately and promptly—a supply and demand index, figures for which are not now available, but have no direct control over the tariff and industry.

The banking system, he said, needed revision. The Federal Reserve System was, to his way of thinking, obsolete and its functions were incomplete. As constituted at present it could serve only one of four essential elements in economic life—industrial production—by rediscounting short-time commercial paper. This left building needs, consumer activity, and speculation beyond the limits of its control. He believed that the Federal Reserve System should be reorganized so as to permit it to exercise control over the entire credit structure of the country. He saw no reason why the Federal banks should not have four discount rates, if necessary, to apply to these four categories of loans, and he felt that this would be preferable to four central banking agencies attempting to exert control. It was his hope that President Hoover would fight strenuously for an amplification of the Federal Reserve System along these lines.

After asserting that the message would contain nothing about prohibition and little about the tariff, Mr. Mazur closed by reviewing briefly the financial situation in Germany.

HOOK ON UNEMPLOYMENT RESERVES

Following Mr. Mazur's address, James W. Hook, president, The Geometric Tool Company, New Haven, Conn., chairman, the Connecticut Unemployment Commission, and a member of the President's Organization for Unemployment Relief, read a paper entitled "The Unemployed—What Shall We Do With Them?"

Mr. Hook's paper was based upon his Silver Bay address, printed in full in the October issue of MECHANICAL ENGINEERING, which described a study of unemployment reserves made at the Geometric Tool Company. His annual-meeting paper represented a comprehensive detailed plan for unemployment relief looking toward the solution of immediate and future difficulties. Dividing the unemployed into three groups—the unemployable, the migratory worker, and the stable employee—Mr. Hook considered their cases in a discussion of the following three principles:

1 Every community should have means for administering charity.

2 Every community with a population of 5000 or more should have a public planning board made up of public officials and private citizens.

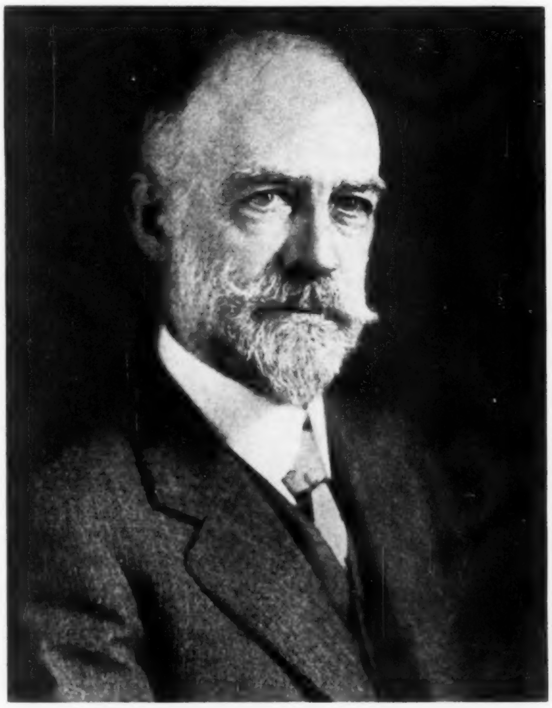
3 Every employer of labor should accept the responsibility for assisting his stable workers during depressed periods of business.

Mr. Hook developed the factors involved under the third principle and discussed in detail the mechanism for accomplishing its implications by setting up employment reserves and benefits as outlined in his Silver Bay address. Among the

points brought out were the overcoming of competitive disadvantage, the basis for calculating the reserve, the effects of the reserve on stabilization of employment, the question of group versus individual plant reserves, what happens when a company goes out of business or when two consolidate, enforcement of the plan, legislative requirements and studies, who should contribute to the reserve, and death and old-age benefits. He was hopeful that voluntary action on the part of the employer would be attainable, because he felt that governmental action should be avoided.

In closing his paper, Mr. Hook called attention to the factor of unbridled competition in driving wages to bare existence levels, and causing overproduction and debt and credit expansion. He made a strong plea for standardized reserve accounting and uniform costing methods so that business could compete on the basis of skilful management and high quality of service and product. He urged that Government "call competitive groups together for the purpose of finding ways and means of controlling production, forecasting consumers' demand, standardizing reserves for depreciation and obsolescence, establishing sound costing practices, and eliminating unfair and cut-throat competition. . ."

The third contributor to the symposium was Dr. Virgil Jordan, economist, McGraw-Hill Publishing Co., New York. His prepared paper, entitled "The Economic Aspects of Stabilization," is printed in full elsewhere in this issue. A careful study of it is earnestly urged upon all engineers.



DR. WILLIAM F. DURAND, TOASTMASTER AT THE A.S.M.E. ANNUAL DINNER

SIGNIFICANCE OF ENGINEERS' INTEREST IN ECONOMICS

It would be improper to pass over the addresses at the stabilization symposium and that by Dean Donham without commenting upon the significance of this quickening interest on the part of engineers in economic problems. Granted that the times demand it and that the services of engineers have always been directed along lines that have a very practical and close connection with industry and trade, there is, nevertheless, an especially helpful contribution that they can make and are making to economic thinking. They are not economists. They are accustomed to accomplishment in the face of great technical difficulties. They are devotees of truth and reason. They are dynamic rather than static by nature. They approach problems with open minds and in a scientific spirit. Their acts are determined by the knowledge of facts. They are bold and optimistic. Thus it is not surprising that among those who are doubtful of the efficacy of economic planning and of the probability of exercising a reasonable amount of control over economic factors and forces they should stand out as strong in their hope and faith that what has not been accomplished in the past may yield to human intelligence in the future. Having accomplished so much in the material world, they are eager to have a go at more subtle and intricate problems, because they find themselves maligned as being responsible for social and economic ills, and because they see the progress of their technological endeavors jeopardized by the breakdown of capitalistic economics. Experiences of their own in the management of small units of human society give them courage. In the confused councils of bewildered economists and chastened financiers their advice should be welcomed, and their persistent spirit of carrying on despite difficulties and disappointments against the seeming hostility of nature should inspire confidence.

In Mr. Hook's paper, for example, is a program which suggests a way out of unemployment difficulties that can be practiced by individual plants and prove its efficacy and practicability on its own merits. At least it is a start, and apparently a good one. That it may need revision, or that it may not offer the ultimate solution, is beside the point at present. It is in operation in at least one plant; and the type of intellect that conceived of it and put it into practice is the type that senses the dynamic and fluid characteristics of society and remains flexibly alert to cope with them.

WHAT THE AMERICAN ENGINEERING COUNCIL IS DOING

Further evidences of this same spirit abound in American industry as exemplified by numerous other excellent plans marked by vigorous individualism and directed toward the common good that are applied to the economy of industrial units. Acting on behalf of the common welfare and with concerted action, the American Engineering Council has made its very practical contribution in the present emergency as explained by L. W. Wallace, executive secretary of the Council, at the A.S.M.E. annual business meeting. This contribution takes the form of three necessary, important, and timely projects, each of which is being initiated, and from which definite conclusions and recommendations can be derived within a year. The projects are:

1 The Emergency Public-Works Plan, designed to expedite and increase the amount of public-works construction in the months immediately ahead for the purpose of relieving unemployment.

2 The Future Public-Works Plan, designed to make a thorough analysis of the question of public works to determine its true place in the national economy and the adjustments of governmental agencies and activities that are necessary to make public works serve a more useful purpose in our national life.

3 An inquiry designed to evaluate the numerous plans suggested for stabilizing business, including the integration of agriculture and industry, and to construct a mosaic in which will appear the major economic factors involved in them so

weighted and placed as to indicate their relative significance.

Two other general lectures of significance were delivered at the A.S.M.E. Annual Meeting. The Robert Henry Thurston Lecture, on a subject in the zone between engineering and science, named for the first president of the A.S.M.E., was delivered this year by Edward L. Thorndike, professor of education, Teachers College, Columbia University, New York, whose subject was "Psychology and Engineering." Professor Thorndike's lecture will be found elsewhere in this issue.

MISS PERKINS DISCUSSES ACCIDENT PREVENTION

On Wednesday afternoon Miss Frances Perkins, industrial commissioner of the State of New York, gave a lecture on "State Labor Departments and Professional Engineers—Co-operation Essential to Progress in Accident Prevention." Miss Perkins declared that an effective labor department in every state was one of the present needs of the United States. She defined an effective labor department as "one which offers leadership in determining what constitutes a good condition of industry," and that "fosters experiment, furnishes expert advice and opinion on all matters pertaining to industrial health and safety, and translates this into terms that everybody can understand." Such a department, Miss Perkins said, was primarily a service organization, to bring the teaching principle into the enforcement of law.

The duty of a labor department, she said, was to prevent accidents, first, by enforcement of the law, second, by recommendations to employers and workers as to safe practices which were beyond the law, and third, by cooperation with all elements in society in solving the technical and sociological problems which were associated with accident prevention.

"A first duty of professional engineers," Miss Perkins said, "is to study the industrial hazards of their particular line of work. In addition, the engineering talents represented by a great organization such as this have a larger responsibility and opportunity. It is to apply to the social and economic structure the same principles that they apply to production, to building, to bridge work. It is possible that the realistic imaginations which are developed out of engineering experience may be just what we need to develop a new and more integrated and satisfactory type of civilization."

NON-TECHNICAL EVENTS

Turning now to matters of Society organization, mention should be made of the conference of Local Sections delegates that met first on Sunday afternoon for organization and subsequently on Monday morning and afternoon and Tuesday morning. Reports of the standing committees of the A.S.M.E. Council were heard, and many subjects of Society interest were discussed. A more complete account of these interesting sessions will be found in the *A.S.M.E. News* for December 22, 1931.

The first social event was a public-speaking contest, won by Victor Sanderson, of Philadelphia, with which was combined a concert by the orchestra of the A.S.M.E. Metropolitan Section, and an exhibit of art by engineers, containing works in oil, water color, crayon, etching, and sculpture done during the past year, and representing a repetition of last year's successful exhibition. Tuesday evening was Presidents' Night, at which Roy V. Wright, retiring president, delivered an address entitled "The Engineer Militant." The text of Dr. Wright's address will be found in this issue. Following the report of the tellers of election of officers for 1931–1932, President-Elect Conrad N. Lauer was escorted to the platform and introduced amid applause. He delivered a brief extemporaneous address consecrating himself to the duties of his new office.

On Dr. Palmer C. Ricketts, president, Rensselaer Polytechnic Institute, was conferred honorary membership. Awards and medals, previously mentioned, were also conferred at this time. A reception and dance followed.

Prominent at the business meeting was the presentation of the report of the Committee on the Economic Status of the Engineer by the chairman of the committee, Conrad N. Lauer. A discussion of the report was led by Prof. Elliott Dunlap Smith, who was instrumental in its preparation. The report appeared in the September issue of MECHANICAL ENGINEERING, under the title, "1930 Earnings of Mechanical Engineers." Appendices to the report appeared in the November and December issues. Professor Smith had previously presented the report to the conference of Local Sections delegates on Monday afternoon.

The annual dinner, held on Wednesday evening at the Hotel Astor, was made the occasion of the conferring of honorary membership on Dr. Calvin W. Rice, as noted at the beginning of this account. The citation was made by Dr. John R. Freeman, past-president of the A.S.M.E., and the certificate of honorary membership and testimonial letters handsomely bound were presented by President Wright.

Following a custom of several years' standing, members elected during the year were addressed by A. A. Potter, dean of engineering, Purdue University. Fifty-year membership badges were conferred upon George M. Bond, William J. M. Dobson, George Hotchkiss Smith, and Frank G. Tallman. Col. Paul Doty conferred the badges. The dinner was presided over by Dr. W. F. Durand, whose extraordinary ability as a toastmaster was so convincingly displayed at the 50th Anniversary Dinner in Washington in 1930. President-Elect Lauer delivered a brief address. Dancing followed the dinner.

TECHNICAL SESSIONS

In a report of an A.S.M.E. annual meeting it is impossible adequately to cover the technical papers and the valuable discussion brought out in their presentation. It would be an oversight, however, not to call attention to some of the high points of the session at which these papers were presented.

Photoelasticity claimed the attention of designing and production engineers in a combined meeting of the Applied Mechanics and Machine Shop Practice Divisions. Cooperating with the Management Division, the Machine Shop Practice Division also turned its attention to the subject of management in machine design and the correlation of casting design and foundry practice. The newly organized Process Committee staged a session on a rational approach to the classification of data on unit operations and industrial processes. At a joint session the Machine Shop Practice Division and the Special Research Committee on the Cutting of Metals listened to papers on the elements of milling and on tungsten carbide and other hard cutting materials.

The Fluid Meters Committee presented two papers on metering, and the Power Division three papers, one describing the 1200-lb Ford steam plant, and the other two, high-pressure boilers of special design, built for pressures above the critical.

The Applied Mechanics and Railroad Divisions got together in a session devoted to the air resistance of high-speed trains and stresses in railroad track. Two sessions were held on lubrication: one, under the auspices of the special research committee on lubrication, was devoted to theoretical problems, and the other, under the auspices of the Petroleum Division, provided a discussion of rolling-mill lubrication.

As usual, the Steam Tables Conference was well attended and intensely interesting. The papers presented will be published in a subsequent issue of MECHANICAL ENGINEERING.

While mention has already been made of the Management Division's stabilization symposium, attention should also be directed to two other sessions, one on engineering economics and the other on management research. Other technical sessions were held under the auspices of the Materials Handling Division, the Fuels Division, the Power Division, the Textile Division, the Iron and Steel Division, the Hydraulics Division, the Aeronautic Division (in cooperation with the American Institute of Physics), the Oil and Gas Power Division, the Committee on Education and Training for the Industries, and the Joint Research Committee on Boiler Feedwater Studies.

Progress Reports of the A.S.M.E. Professional Divisions were also presented. A summary of these reports will be found in the December, 1931, issue of MECHANICAL ENGINEERING.

TECHNICAL-COMMITTEE MEETINGS

Forty-three technical committees met during this annual meeting of the Society. These meetings with a total attendance of approximately 539 were devoted to research, safety, standardization, boiler codes, and power test codes.

The research committees were responsible either solely or jointly for the seven technical sessions: metal cutting, fluid meters, lubrication, fuels, steam tables, symposium on steel-mill bearings, and boiler-feedwater studies.

The twenty-one meetings on standardization had an attendance of slightly more than three hundred. The standards projects discussed at these meetings were: shafting, small tools and machine-tool elements, T-slots, circular forming tools and their holders, milling-machine tables, screw threads for hose couplings, speeds of machinery, wrench-head bolts and nuts and wrench openings, scientific charts for lantern slides, pressure and vacuum gages, pressure piping, taper pipe threads, allowances and tolerances for cylindrical parts and limit gages, steel pipe flanges and flanged fittings, and pipe and tubing for low- and high-temperature services.

One notable feature of the technical-committee-meeting program was the organization of a joint A.P.I.-A.S.M.E. committee on a Code for Unfired Pressure Vessels for Flammable Liquids and Gases. Walter Samans was elected chairman, and Dr. R. P. Anderson, secretary of the joint committee.

EXCURSIONS

New York City provides excellent facilities for interesting and instructive excursions, and these excursions have become an important feature of the annual meetings. Ships, power stations, museums, and industrial plants form the majority of the objectives. Among the unusual opportunities afforded this year were visits to the new Empire State and McGraw-Hill buildings.

WHOM TO THANK

No one could ever correctly estimate the value of an A.S.M.E. Annual Meeting in terms of its cost in money, directly and indirectly expended, and in human effort. Represented by the well-balanced but varied program of closely knit technical sessions, committee meetings and reports, and social events are the vision and planning of the A.S.M.E. Meetings and Program Committee, but back of all lie the work and interests of thousands of engineers who have reported their experiences and the results of their studies and who have cooperated in committee activities for the good of the profession. Years of research study and practical experience, thousands of dollars' worth of time and materials, hours of struggle with pencil and paper to produce a report or technical paper, have been fleetingly exhibited for the few brief minutes allowed for presentation and discussion. In the great number of these highly concentrated evidences of so much hard work, individual efforts are inadequately appreciated by the average engineer who is faced with so many demands upon his interest and attention. Perhaps many an author or committee member has gone away discouraged and disappointed that his work has met with such scant notice. Let him take heart. Present appraisal is not permanent. If his effort has been sincerely made it will have been a helpful contribution to many, and its influences may be more far-reaching than he dares to hope. In spite of an apparently inattentive attitude with which many papers are received, the engineering profession is sincerely grateful for these evidences of a spirit of cooperation and a desire to contribute to knowledge, and realizes that its future lies in the building up of this spirit and in the progress of its recorded knowledge.

LOCAL SECTIONS DELEGATES AT ANNUAL MEETING

THE PITTSBURGH COAL CONFERENCE

Third International Gathering Considers the Problems of the Bituminous Coal Industry

LIKE its predecessors, the Third International Conference on Bituminous Coal was held at the Carnegie Institute of Technology in Pittsburgh. It differed from the other conferences in that it was expanded to comprise the economic and, to some extent, political features of the coal industry, which was natural as for the time being they far outweigh technical questions in immediate importance to this much harassed industry. Broadly, the work of the conference, which sat in the third week of November last, had to do with general economics; competition of coal with other sources of heat and power generation; powdered coal; low- and high-temperature carbonization; gas production; and mining and geology of coal.

POWDERED COAL

The jet-impact pulverizer belongs to the class of undriven mills in which the material to be ground is supplied with energy of motion by a jet of air or liquid, and this energy is converted into work of friction or impact. These mills may be operated either with high- or with low-pressure air. A report by Prof. Karl S. Glinz dealt with this latter type and compared it with high-pressure pulverizers, after which the author stated the technical requirements for low-pressure pulverizers and described a pulverizer built according to the Anger patents. Five boiler plants using bituminous coal are fired with these pulverizers in Germany.

The slag-tap furnace and its effect upon the selection of coal for burning in pulverized form was discussed by E. G. Bailey and R. M. Hardgrove. Among the advantages of this type of furnace the authors mentioned its high ash recovery (40 to 50 per cent instead of 10 to 15 per cent in dry ash removal) and its ability to burn the coal completely. There are also interesting possibilities in the profitable utilization of disintegrated slag from slag-tap furnaces for concrete, slag wool, etc. Reference was made by the authors to the Research Committee of The American Society of Mechanical Engineers on fluxes intended to make the ash fluid at lower temperatures.

R. J. McKechnie told about the burning of pulverized coal on shipboard. He stated that the successful operation of pulverized-coal firing in this service was due to the consistent fine pulverization of the fuel and strict attention to their routine duties by the engine-room personnel. Under load the mills were quiet in operation. No trouble had been experienced, he said, in maintaining operation with either new material or Pocahontas half-slack coal. The paper dealt with the performance of three ships equipped with different types of pulverizers.

Another paper on the same subject was presented by Ch. H. Stein, of Paris, who described European progress in the use of powdered coal in steamships and set forth the special conditions to be met in marine installations, of which absolute safety, danger of fire, and reliability of operation are foremost. The design submitted by the author employs a Scotch boiler with the furnace partially lined with a layer of refractory material, and a burner of the turbulent type.

The method of distributing the combustible mixtures to the various furnaces was described in detail, and a short description of some European installations was appended.

The mechanism of combustion of pulverized coal was discussed by A. Grebel, of Paris. Among the conclusions at which he arrived was that further research on the subject is still necessary. The time of combustion of a spherical particle, he said, is roughly proportional to a function of the original diameter, and the effect of air speed, while not negligible, is not of prime importance. A curve indicating the temperature of the particle and that of the walls as affecting the speed of combustion is given in the paper.

The practical and theoretical aspects of firing low-grade bituminous coal in pulverized form were presented by E. H. Tenney. Extremely rapid burning of pulverized coal, indicated by research work where burning times of 0.2 to 0.8 sec were encountered, he said, is also found in a large commercially operated furnace where the air and coal are thoroughly mixed before delivery to the furnace. With streamline firing and delayed secondary-air admission (on the particular type of installation under observation), slow and ineffective mixing results in much slower ignition and combustion.

In the large furnaces studied extremely rapid combustion could not be utilized by reducing furnace volume since the resulting higher heat liberation per cubic foot would cause either excessive furnace exit-gas temperature (and slagged generating tubes) or excessive damage to side walls, or both.

The rapid combustion found in the installation of horizontal turbulent firing permits operating with less excess air than is necessary in the case of streamline firing, results in a clearer flame, and reduces the tendency for slagging in the pit. These points are supported by actual records which show less outage for cleaning slag and lower steam costs.

Railroad engineers will be interested in Richard O. Roosen's (Kassel, Germany) paper on "Trial and Road Results with Stug Pulverized-Fuel-Fired Locomotives." A paper on the same subject was read before the December, 1930, meeting of the A.S.M.E.

Another paper on pulverized coal for steam locomotives was presented by J. C. Chapple, of St. Louis, Mo. The unit system of pulverization is here used, but a comparison of the unit and storage system is given.

The general subject of railway fuel was discussed in a paper by H. C. Woodbridge, of Rochester, N. Y., C. P. Dampman, of Philadelphia, Pa., and Malcolm Macfarlane, of New York. The authors dealt with fuel burned on grates and set up the ideal requirements for the handling of such fuel. The experience of a modern locomotive stoker feed was cited where from 39 to 42 per cent volatile coal was burned without smoke while the engine was worked. In connection with preparation of coal, stress was laid on the use of an electromagnet to remove foreign metal.

FUEL RESEARCH

Some aspects of fuel research, particularly as dealing with the work of the Fuel Research Division of the Department of Scientific and Industrial Research, were told by F. S. Sinnatt, of Greenwich, London. These dealt with low-temperature carbonization, pulverized fuel, and hydrogenation of tar. Two new forms of apparatus for the combustion of powdered coal in confined spaces were described, the grid burner and the

vortex combustion chamber. The author showed by analysis that the logical method of burning coal in a small combustion chamber was not to induce turbulence but to subject the fuel particles to some force causing them to travel across a current of air flowing in streamlines. He showed mathematically that the effect of radial pressure gradient in the so-called turbulent boilers might safely be neglected.

The mechanism of combustion of solid fuel formed the subject of a paper by S. P. Burke, of West Virginia, and T. E. W. Schumann, of Pretoria, South Africa, who set up a theory that in the final analysis the rate of combustion was controlled by the composition of the atmosphere, the pressure, the temperatures of the sphere, the ambient fluid, and the furnace walls, the size of the sphere, the thickness of the film, and similar factors. The mathematical part of the article is not suitable for abstracting.

The value of clean coal for steam generation was discussed by Edwin B. Ricketts, of New York, who gave a formula for calculating the effect of variations in ash content on the value of coal to the consumer.

The practical question of burning bituminous coal on large underfeed stokers was discussed in considerable detail by Bert Houghton, of Brooklyn, N. Y., who pointed out the temperature limitations in stoker operation and the danger of the practice of reducing the excess air to limits which, on close analysis, were not consistent with the best operating economy.

The details of regulation of air and movement of fuel, he said, were of the utmost importance if all the sections of the stoker were to function properly at comparatively uniform rates of heat release. As regarded cinder loss, the author gave curves which showed that at an evaporation of 200,000 lb per hr, the maximum increase in boiler efficiency attainable by the total elimination of cinders was 0.5 per cent, this gain gradually increasing to 10.3 per cent at an evaporation of 340,000 lb per hr. While some volatile combustible entered the ashpit, the latter was not a fuel-burning adjunct of the stoker. The key to the solution of the stoker operator's problem was the proper physical manipulation of the stoker to produce the desired fuel-bed characteristics.

The elimination of sulphur compounds from boiler-furnace gases formed the subject of a paper by H. F. Johnstone, which described an investigation carried out at the University of Illinois. This covered the cleaning and processing of coal, the reactions of sulphur compounds in boiler furnaces, the washing of flue gases, which included catalytic reduction of sulphur dioxide to free sulphur, and the use of dissolved oxidizing catalysts.

GAS MANUFACTURE

Recent developments in intermittent vertical-chamber plants were described by L. H. Sensicle, of London, England He emphasized the flexibility of this type of equipment in choice of coal and in output, which latter was readily changed by altering the flue temperature, and in quality of the gas made, which permitted producing efficiently any calorific value in the range from 300 for blue water gas to 560 for "straight" carbonization gas.

Experiments on carbonization of bituminous coal in streams of gases were described by J. H. Scholtz and R. V. Wheeler, of the University of Sheffield, England. It was desired to determine whether and to what extent the use of a stream of gas during the carbonization of bituminous coal at a low temperature would affect the quantity and character of the oils and gases thus swept from the retort, as well as to estimate the value of superheated steam as the carbonizing medium.

It was found that the design of the retort affected the oil yield considerably, and the use of superheated steam, and to a lesser extent the use of streams of hot gases, during low-temperature carbonization increased the yield of oil and, to a minor extent, of gas. The quality of the semi-coke was not materially affected.

The large water-gas generators in use in Great Britain were described by N. E. Rambush, whose conclusion was that the limit of economy obtainable in regard to both capital and labor cost by increasing the size of unit was governed entirely by the largest capacity demanded by future industrial requirements. For present conditions the existing units of 10,000,000 cu ft are the economic limit of capacity of water-gas generators for using coke, but should bigger units be demanded, they could be built.

According to Dr. Carlo Padovani, of Milan, Italy, in a paper entitled, "Chemical Utilization of Methane," a number of products can be obtained by the pyrolysis of methane at temperatures between 1000 and 1300 C, but the industrial future of the process depends on the quality and possible commercial uses of lampblack, the properties of which may be appreciably altered by changing the working conditions.

The synthesis of lubricating oils from coal and its gaseous products was considered possible by A. W. Nash, of the University of Birmingham, England, both from the scientific and technical viewpoints. He hoped that in this way also light would be shed upon the constitution of lubricating-oil fractions of natural petroleum of different types, but stated that the problem was not one of the immediate future in any country where petroleum supplies were available, either indigenous or imported.

A German process of producing water gas from powdered fuels by the Heller apparatus was described by A. Thau, of Berlin, Grünewald. Essentially, this procedure consists of a stationary horizontal cylinder divided into a number of vertical cells arranged like a battery of by-product coke ovens, so that alternately one cell serves as a heating chamber and the next one as a gasifying cell. The trial unit erected at the Berlin Gas Works was described.

The Winkler process of gasification of fine-grained coal was described in a paper by Prof. H. G. Grimm, of Ludwigshafen, Germany.

COAL CARBONIZATION

John Roberts, of London, England, discussed the subject of blending, with special reference to the Davidson rotary retort. He told about the properties of banded coal and of reasons for precarbonization treatment. His suggestion was that coal should be oxidized at low temperatures as a preliminary to carbonization. He believed that an attempt to produce fuel oils from coal had been largely responsible for heavy financial failures and enormous waste of effort, and recommended concentrating on the maximum yield of smokeless domestic solid fuel and leaving oil more or less alone. The theoretical part of the paper dealt with the Davidson retort generally and the influence of coal on the character of spheroids.

Horace C. Porter, of Philadelphia, Pa., told of experimental research on the subject of the fluidity of coking coals softened by heat. In this research the great differences in fluidity of coals were shown by an orifice-flow method. This affected coke making, combustion on underfeed mechanical stokers, and gasification in producers and gas generators.

Philip C. Pope, of London, England, made an attempt to state the present position and future prospects of low-temperature carbonization and distillation of coal in Great Britain. He was rather skeptical about the prospects of both low-tem-

perature carbonization and hydrogenation, and was looking for other methods which might be the means of giving the necessary products or their equivalents in proportions more easily regulated than was the case today. In his opinion, one of the primary difficulties inherent in the nature of the problem was the poor conductivity of the coal itself. The use of thin layers and oil as a vehicle for heating the coal had been tried, and steam superheated to carbonization temperature was advocated. The author did not believe in the effectiveness of the latter process, and suggested that some attention be paid to the use of powdered coal in commercial-sized low-temperature plants.

Another paper on blending coal for coke making was presented by R. A. Mott and R. V. Wheeler, of Sheffield, England. The authors claimed that they had been saved from a medieval spirit of intolerance by the fact that they had been led to search for the truth rather than believe that they had started with it.

The Salerni system of low-temperature carbonization was described by Prof. R. V. Wheeler, of Sheffield University, England. In this system the swelling properties of the coals were controlled by blending with a non-coking material—finely ground semi-coke breeze from the process itself. This introduced a cementing material, mainly a low-temperature oil. The process was described in some detail in the paper.

Fusibility and caking of bituminous coal as affecting the choice of coal for metallurgical coke, was discussed by Geo. L. Stadinkoff, of Karpov Institute, Moscow. The author established constitutional criteria of caking and discussed the influence of the petrographic constituents on the coking of coal.

"Steaming in Continuous Vertical Retorts" was the subject of a paper by Dr. M. Barash and T. A. Tomlinson, of Manchester, England, and gave the history of the subject and told about the steaming reaction and the nature of the "added" gas.

Dr. R. P. Soule, of New York, spoke of low-temperature carbonization, its rise to prominence in the public eye, and its fall from grace. His paper is critical and historical, and not suitable for abstracting.

The same subject of low-temperature carbonization was broadly discussed by Leopold Herry in connection with the utilization of coal at the Langerbrugge Central Station in Belgium. At that station, the author said, industrial results had been reached that required only development on a much larger scale in order to provide the electric plant with a lower cost per kilowatt-hour and the nation with domestic fuel. A comprehensive abstract of this paper will appear at an early date in the Engineering Survey Section of MECHANICAL ENGINEERING.

HYDROGENATION, DISTRICT HEATING, SMOKE ABATEMENT, AND OTHER PROBLEMS

An extensive paper was presented by Prof. H. G. Grimm on the processing of coal and oil, with special regard to catalytic high-pressure hydrogenation. It was based on the work done by Dr. C. Krauch and Dr. M. Pier and their collaborators, and set forth the range of the processes to which high-pressure hydrogenation could be applied.

Jose Manuel Pertierra, of the University of Oviedo, Spain, spoke about the colloidal solution of coal, claiming that the action of solvents on coal at elevated temperatures had not been thoroughly studied. He had submitted a coking coal to the solvent action of aniline, pyridine, and quinoline at their boiling points, and had calculated the amount of dissolved coal.

A. R. Mumford of New York told about the use of bituminous coal in district heating. His paper was largely of an economic character.

As regarded prevention of smoke in metallurgical operations, the most satisfactory ultimate solution of the whole problem, in the opinion of Prof. C. H. Desch, University of Sheffield, England, would be found in the application of electric heating, which would moreover provide control of the atmosphere.

An extensive paper on rationalizing smoke abatement was presented by Victor J. Azbe, of St. Louis, Mo. In it the author discussed the harmful effects of smoke, asserted that smoke could be eliminated, told of its gases and nature, including measurement of atmospheric pollution, and recommended methods for combating it, both with respect to domestic heating plants and to industrial plants.

THE FUTURE OF COAL

Wm. A. Forbes, assistant to the President of the United States Steel Corporation, told of the future possibilities of bituminous coal in the United States. He discussed the manufacture of coke, replacement of coal by other fuels, hydrogenation of coal, etc., and incidentally quoted some very significant figures.

In 1929, he said, 44,716,378 gross tons of coal equivalent were used in the production of 21,868,816 tons of steel ingots and castings, which figured to 4580 lb of coal per ton of ingots. Of this coal-equivalent consumption, 33,077,847 gross tons were used as raw coal, or 74 per cent, and 11,638,531 gross tons of coal equivalent, or 26 per cent, were used as substitutes, similar to those referred to in 1920 practice. Thus in 1929, as compared with 1920, 2,590,856 tons more steel were produced and 2,191,855 tons less total raw coal and coal equivalent were consumed. Of these amounts, the reduction in actual coal consumed in 1929, as compared with 1920, was 4,633,028 gross tons, while the coal equivalent of substitute fuels amounted to 2,441,173 gross tons more in 1929 as compared with 1920.

Summing up these figures, it will be found that in producing 2,590,856 tons more steel in 1929 than in 1920, 4,633,028 less gross tons of coal were mined, a striking example of the advance in efficiency and substitute fuels, all of which substitute fuels were by-products of coal, with the exception of fuel oil and natural gas, and waste heat reclaimed.

Fuel-oil consumption was 55,061 gross tons coal equivalent less in 1929 than in 1920, and natural-gas consumption was 282,541 gross tons coal equivalent less in 1929 than in 1920, while waste heat reclaimed was 396,577 tons coal equivalent more in 1929 than in 1920.

The same problem was dealt with by C. E. Bockus, president of the National Coal Association, in a paper entitled, "The Causes of Excess Productive Capacity of Bituminous Coal Mines." His suggestion was an economic limitation of coal production, and he believed that unless some such character-fuels were by-products of coal, with the exception of fuel oil, natural gas, and waste heat reclaimed.

Several papers were presented dealing with competition between bituminous coal and other sources of energy. A comprehensive abstract of these is planned for an early issue of MECHANICAL ENGINEERING.

Two papers dealt with the coal-dust engine. One by Rudolph Pawlikowski was a report on recent developments of the Rupa engine, which is a Diesel type. The other paper, by Tatsuro Suwa, dealt primarily with the combustion properties of various kinds of coal and self-ignition temperature of coal-air mixtures as a basis for the design of coal-dust engines. These papers will also be abstracted in an early issue of MECHANICAL ENGINEERING.

BOOK REVIEWS AND LIBRARY NOTES

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Trustees, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

A Broad Vision of Organization

PRINCIPLES OF ORGANIZATION AS APPLIED TO BUSINESS. By Henry P. Dutton. McGraw-Hill Book Co., 1931. Cloth, $5^3/_8 \times 8$ in., 315 pp., with 9 figs., 3 tables, and index, \$3.

REVIEWED BY CROSBY FIELD[1]

ONCE in a blue moon there appears a comprehensive, readable book on a hackneyed subject that presents its material in so interesting a fashion and on so broad a basis that all the reviewer can do is to say, "By all means read this book. Not to have read it must be considered a real loss." And such a book is the one now presented.

It is no mere elaboration of a pet method of organization, with charts appended, for the reader to mentally insert the names of his associates, but an inquiry into the forms of all organized growth and the principles underlying it, with particular application to business laws first formulated in the sciences and arts: e.g., physics, psychology, politics, biology, sociology, civics, military strategy and tactics, economics, ethics, mechanics, etc. Nor are the examples chosen in any way hodge-podge; each is a well-selected and well-developed case story, especially pertinent to the business phase under discussion.

So succinctly are the principles summarized, and so illuminating the examples, that although the reader may not realize it, he has obtained a most complete foundation on which to build and operate his own specific organization. From this viewpoint Mr. Dutton has prepared a sugar-coated handbook, lacking only the specific dollars-and-cents or man-hour data usually given in books of that classification.

The footnotes comprise a most unusual bibliography limited only by the scope and the outline of the book itself.

In addition to the normally anticipated chapters such as, say, Measurement and Training, and Incentive and Discipline, there are also welcome ones on such subjects as Group Thinking and Decision, Creative Thinking, and the Organization of Thought. In his last chapter, on the Organization and Its Outside Relations, the author permits himself to wander—in the writer's opinion to his own detriment—into that field where idealism alone can be invoked to bolster up the indicated, the not completely expressed, conclusions.

This is a most "practical" book in all other aspects, yet its literary value is so high that it would be unfair not to include a sample. Therefore one out of many similar paragraphs is appended.

[1] Vice-President, Brillo Mfg. Co., Inc., and President, Flakice Corp., Brooklyn, N. Y. Mem. A.S.M.E.

"Leadership depends on wisdom, that it may not lead to defeat and destruction, and on organized habits of performance, that it may not be submerged in detail. Yet both these qualities are easier to obtain and may more easily be drawn from secondary sources than that determination whose constant weight overbalances the shifting forces of chance, and supplies the flame of imagination and daring which consumes the irresolutions of lesser souls."

Industrial-Accident Prevention

INDUSTRIAL ACCIDENT PREVENTION: a Scientific Approach. By H. W. Heinrich. McGraw-Hill Book Co., Inc., New York, 1931. Cloth, $5^1/_2 \times 8$ in., 366 pp., illus., \$4.

REVIEWED BY M. G. LLOYD[2]

THE author has incorporated in this book the ideas which he has previously made public regarding the proper analysis of causes of accidents and the classification of accidents according to cause. This analysis is fully developed, and the thesis that nearly all industrial accidents can be controlled and that the responsibility for controlling them depends upon the employer, is very thoroughly developed. The companion thesis that the hidden costs of accidents exceed the visible costs of compensation and medical attention in the ratio of 4 to 1, is given similar attention. The author has analyzed thousands of accident reports and cites many individual cases to illustrate the points which he brings up. He states that 98 per cent of the accidents are preventable, and that the prevention of 88 per cent of them depends upon proper supervision, which in turn depends upon the executive management of the industry.

A chapter of 100 pages is devoted to the physical guarding of machinery, and is very fully illustrated by actual installations of each type considered. In the effort to emphasize the proper analysis of causes and their proper treatment to eliminate accidents, many lines of work for the safety engineer have necessarily been left undeveloped. The author does, however, devote one chapter to illumination, showing how inadequate illumination contributes to the occurrence of accidents. The book contains 11 appendices, comprising among other things reproductions of published articles, reports from different companies, statistics, the insurance rating schedule, and a short bibliography of references covering the principal subjects covered by the text.

[2] Chief, Section of Safety Standards, Bureau of Standards, Department of Commerce, Washington, D. C.

Books Received in the Library

A.S.T.M. TENTATIVE STANDARDS, 1931. Philadelphia, American Society for Testing Materials. 1008 pp., illus., diagrs., charts, tables, 6 × 9 in., cloth, $8; paper, $7.

This book contains the tentative specifications, methods of test, and recommended practices which had been proposed to the Association but had not been formally adopted in September, 1931. Although they are not official, they represent the latest thought of the committees and are widely used. One hundred and eighty standards are given, 42 of which appear for the first time. Among the latter are standards for structural steel for ships, helical springs, steel forgings for locomotives, steel pipe, alloy castings, wall board, concrete aggregates, soluble nitrocellulose coatings, insulating materials, and rubber hose.

CONVERSION EQUIVALENTS IN INTERNATIONAL TRADE. By S. Naft. Philadelphia, Commercial Museum, 1931. 357 pp., tables, 6 × 9 in., cloth, $5.

This is an unusually comprehensive collection of weights and measures and will be of great value to calculators generally. Factors and tables for converting the units of all countries are given in more than usual detail, and the information is tabulated alphabetically and geographically, as well as by systems. Attention is paid to compound conversions and to special measures used in engineering, commerce, and various industries.

DAUERFESTIGKEIT VON STÄHLEN MIT WALZHAUT OHNE UND MIT BOHRUNG VON NIET- UND SCHWEISSVERBINDUNGEN. By O. Graf. Berlin, VDI-Verlag, 1931. 42 pp., illus., diagrs., charts, tables, 6 × 9 in., paper, 6.50 r.m.

Describes a series of fatigue tests of various structural steels which were made upon ordinary shapes and structural elements in the usual condition instead of upon polished specimens of selected form. Roll skin and holes were found of notable influence upon endurance.

DIESEL REFERENCE GUIDE. By J. Rosbloom. Jersey City, N. J., Industrial Institute, Inc., 1931. 292 pp., illus., diagrs., charts, tables, 8 × 10 in., cloth, $10.

This volume, intended as a reference work for Diesel-engine owners, manufacturers, and operators, brings together in convenient form much practical information. The theory and construction of the engines, their installation and management, accessories, fuels, repairing, and similar topics are discussed, and there are descriptions of locomotives and airplane and automobile engines. Diesel-engine installations in America are listed, and there is a list of the installed engines of over 1000 hp. A section provides a directory of manufacturers of and dealers in engines and accessories.

ECONOMIC CONTROL OF QUALITY OF MANUFACTURED PRODUCT. By W. A. Shewhart. New York, D. Van Nostrand Co., 1931. 501 pp., illus., diagrs., charts, tables, 6 × 9 in., cloth, $6.50.

Dr. Shewhart has written an important work upon the use of statistical methods in the study of the problem of controlling the quality of manufactured articles. Using as an illustration the experience of the Bell Telephone Laboratories in developing the most efficient ways of applying these methods to the problems that arise in manufacturing, he explains clearly the mathematical and statistical principles that are involved, and shows how they are applied to actual problems. His book is an interesting exposition of new methods for the study of industrial problems which are coming into use. Contents: Introduction; ways of expressing quality of product; basis for specification of quality control; sampling fluctuations in quality; statistical basis for specification of standard quality; allowable variability in quality; quality control in practice; bibliography.

ELEMENTS OF MACHINE DESIGN—Part II. By W. C. Unwin and A. L. Mellanby. New and revised edition. London and New York, Longmans, Green & Co., 1931. 450 pp., illus., diagrs., charts, tables, 6 × 9 in., cloth, $4.

In preparing the new edition of this well-known textbook, the reviser has kept close to the original purpose of Professor Unwin, with such alterations in the text as were suggested by modern experience and research. Additional information is given upon torsional oscillations and methods of estimating sizes by consideration of critical speeds. An improved method is given for analyzing the stresses in flywheels, and more data are given upon the strength of flanged joints and on link motions. Minor alterations and additions occur throughout.

DER SCHNITTVORGANG IM SANDE. Forschungsheft 350. By J. Rathje. Berlin, VDI-Verlag, 1931. 24 pp., illus., diagrs., charts, tables, 9 × 12 in., paper, 5 r.m.

In this investigation of the action of the shovels of excavating machines, special attention was given to the influence of the shape of shovel blades upon the earth resistance. Interesting comparisons are made between the plastic deformation of sand and of metals and between the phenomena of cutting two materials.

LE GRAISSAGE DES TURBINES À VAPEUR ET DES MACHINES ROTATIVES A GRANDE VITESSE. By P. Martinet. Paris, Dunod, 1931. 167 pp., illus., diagrs., charts, tables, 7 × 10 in., paper, 40 fr.

Lubricating oils are here treated from two points of view: their properties, and the changes that they undergo during use, especially in steam turbines. Among the topics are the oxidation of lubricants, the physical and physico-chemical properties of oils, the formation of emulsions, fluid friction, oil circulation in steam turbines, and the purification of used oil. Methods of examining and testing oils are given. The book summarizes the investigations on the subject and offers practical suggestions.

HYDRO- UND AEROMECHANIK. NACH VORLESUNGEN VON L. PRANDTL. By O. Tietjens. Berlin, J. Springer, 1931. 299 pp., illus., diagrs., charts, tables, 6 × 9 in., cloth, 23 r.m.

Dr. Tietjens' book is based upon his notes of Dr. Prandtl's lectures at Göttingen, but includes also much additional material. The first volume is largely theoretical: the mechanics of liquids and gases and the dynamics of frictionless fluids are discussed. The second volume is more closely related to practical problems: flow in pipes and channels, resistance of submerged bodies, buoyancy, etc. It contains a chapter upon laboratory equipment and methods. The manuscript was read by Dr. Prandtl, who has added valuable new material.

INTERNATIONALE SPRACHNORMUNG IN DER TECHNIK, BESONDERS IN DER ELEKTROTECHNIK. By E. Wüster. Berlin, VDI-Verlag, 1931. 431 pp., charts, tables, 7 × 10 in., cloth, 20 r.m.

A great deal has been done in different countries to standardize the terminology of engineering, but little consideration has been given to means of international intercourse. The present book discusses this subject in detail. The author first investigates the structure of engineering terms in the principal languages, and their development. The methods which have been used to standardize these terms internationally are discussed, and the limitations of each pointed out. The conclusion is reached that an artificial international language is the best means, and the advantages of Esperanto are set forth. Incidentally, the book affords much information upon the definitions and terms adopted by engineering standards associations all over the world.

CURRENT MECHANICAL ENGINEERING LITERATURE

Selected References From The Engineering Index Service

(The Engineering Index Service Is Registered in the United States, Great Britain, and Canada by the A.S.M.E.)

THE ENGINEERING INDEX SERVICE furnishes to its subscribers a Weekly Card Index of references to the periodical literature of the world covering every phase of engineering activity, including Aeronautic, Chemical, Civil, Electrical, Management, Mechanical, Mining and Metallurgical, Naval and Marine, Railway, etc. Of the many items of particular interest to mechanical engineers a few are selected for presentation each month in this section of "Mechanical Engineering." In operating The Engineering Index Service, The American Society of Mechanical Engineers makes available the information contained in the more than 1800 technical publications received by the Engineering Societies Library (New York), thus bringing the great resources of that library to the entire engineering profession. At the end of the year all references issued by the Service are published in book form, this annual volume being known as "The Engineering Index."

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

AIR CONDITIONING

COOLING WITH ICE. Air Conditioning Versus Space Cooling, M. D. Woodling. Ice and Refrig., vol. 81, no. 5, Nov. 1931, pp. 269–275, 17 figs. Use of manufactured ice as cooling medium; effect of air temperatures upon human body; development of mechanical devices for cooling; illustrated description of Du-All unit cooler; details of specific installations.

Air Cooling With Ice. Ice and Refrig., vol. 81, no. 4, Oct. 1931, pp. 207–211, 10 figs. Problems to be met in designing system for cooling air with ice; proper interior temperature; methods of cooling air; description of equipment designed by Betz Unit Air Cooler Co.; successful installations.

EQUIPMENT. Air Conditioning; Apparatus—XI and XII, W. H. Stangle and R. E. Cherne. Heat. and Vent., vol. 28, nos. 7 and 10, July 1931, pp. 84–91 and Oct., pp. 70–74, 13 figs. Practical discussion of methods of determining equipment requirements; equipment design and operation; winter operation; characteristics of standard humidifiers; summer operation; dehumidification calculations; air reheating and reheater; sizing reheater ahead of fan; sizing reheater in recirculated air chamber.

Air Conditioning by Gas in the New Gas Headquarters at Dallas, Texas, L. A. Bickel. West Gas, vol. 7, no. 10, Oct. 1931, pp. 32–33 and 60, 3 figs. Installation consists of silica gel dehydration plant and mechanical refrigerator to cool air after proper relative humidity has been obtained; experiments being conducted on gas-fired refrigerator to replace mechanical one; cycle of operation; details of equipment.

[See also *Cars—Passenger*.]

AIRPLANE ENGINES

BEARINGS. Bearing-Load Analysis and Permissible Loads as Affected by Lubrication in Aircraft Engines, F. L. Prescott and R. B. Poole. Soc. Automotive Engrs.—Jl., vol. 29, nos. 4 and 5, Oct. 1931, pp. 296–315 and Nov. pp. 379–389 and (discussion) 389–390, 23 figs. partly on supp. plate. Rapid calculating method; analysis of bearing loads in Curtiss V-1570 Conqueror engine by graphic method; crankpin bearing loads.

OPPOSED-PISTON. Dawn Opposed Piston Engine. Aero Digest, vol. 19, no. 4, Oct. 1931, p. 89, 1 fig. Operating principles of five-cylinder radial, four-cycle, air-cooled engine by Dawn Motors, Ltd., of Los Angeles, Calif.; two opposing pistons in each cylinder, outer pistons serving as moving cylinder head; elimination of stresses in cylinder and crankcase; bore and stroke 4.125 by 3.750 in.; 110 hp. at 1450 r.p.m.

RACING. The Evolution of a Schneider Engine, F. R. Banks, Aeroplane, vol. 41, no. 15, Oct. 7, 1931, 5 pp. between pp. 864–872, 6 figs. Testing methods and equipment used in development of "R" type aero engine; developing 2350 hp. at 3200 r.p.m.; total weight 1639 lb., or 11 oz. per b.hp., and nearly 200 b.hp. for each cylinder.

SALMSON. Concerning Salmson Aero Engines. Aeroplane, vol. 41, no. 17, Oct. 21, 1931, pp. 974, 976, 978, and 980, 9 figs. Production methods at plant of British Salmson Aero Engines, Ltd.; AD 9 is 9-cylinder radial air-cooled engine of 2.76 in. bore and 3.386 in. stroke which weighs 154 lb.

AIRPLANES

AUTOGIROS. See *Autogiros*.

METAL CONSTRUCTION. Versuchsentwicklung in Metallgeruestbau (Experimental Development in Metal Construction), A. Koppenhoefer. Zeit. fuer Flugtechnik und Motorluftschiffahrt, vol. 22, no. 14, July 28, 1931, pp. 421–425, 18 figs. Comparison of test results on different types of metal construction, particularly for wing spars, including steel, duraluminum, and electron; advantages of welded and riveted construction.

PASSENGER. L'avion Sabca S. XII (Airplane Sabca S. XII). Conquete de l'Air, vol. 27, no. 10, Oct. 1, 1931, pp. 679 and 681, 3 figs. Design and performance of high-wing monoplane equipped with 3 Renard engines of 120 hp. each; span, 18 m.; useful load, 500 kg. (for passengers and freight); weight empty, 2000 kg.; total weight, 2864 kg.

PROPELLERS. Ueber die Goldsteinsche Loesung des Problems der Luftschraubs mit endlicher Fluegelzahl (Goldstein Solution for Propeller of Finite Blade Number), H. B. Helmbold. Zeit. fuer Flugtechnik und Motorluftschiffahrt, vol. 22, no. 14, July 28, 1931, pp. 429–432, 5 figs.; see also translated abstract in Mar. Engr. and Motorship Bldr., vol. 54, no. 649, Oct. 1931, p. 397. Prandtl developed expressions for reduction in induced velocity on blade element as function of radial position of element, number of blades, etc.; Goldstein showed that this solution is merely special case of more general one, circulation depending also upon tip pitch angle, divided by blade number; consequences of theory are investigated.

SEAPLANES. See *Seaplanes*.

TAILLESS. The New German "Tailless," E. P. A. Heinze. Flight, vol. 23, no. 41, Oct. 9, 1931, pp. 1008–1009, 5 figs. Features of all-wing-type cantilever monoplane equipped with 30-hp. Cherub engine driving pusher propeller; cockpits covered by hinged hoods; span of wing, 42.65 ft.; fully equipped machine weighs 794 lb.; gross flying weight, 1144 lb.; wing loading, 4.25 lb. per sq. ft.; power loading, 39.4 lb. per b.hp.; maximum speed, 96.4 m.p.h.

ALLOYS

BEARING METALS. See *Bearing Metals*.

BRASS. See *Brass*.

COPPER-SILICON. See *Copper-Silicon Alloys*.

CONSTITUTION. Die Neuere Entwicklung der Konstitutionsforschung der Legierungen (Recent Development in Research on the Constitution of Alloys), W. Guertler. Int. Congress Testing Matls.—Advance Paper, 1931, 15 pp. General review of factors that have led recently to reconstruction of nearly all equilibrium diagrams; enumeration of contributing factors; compilation of some of most outstanding researches; only binary alloys are dealt with. Bibliography.

ALUMINUM

CASTINGS, DEFECTS IN. Unsoundness in Aluminium Sand Castings, D. Hanson and I. G. Slater. Foundry Trade Jl., vol. 45, nos. 788, 789, and 790, Sept. 24, 1931, pp. 193–196, Oct. 1, 209–213 and Oct. 8, pp. 225–227, 21 figs. Sept. 24 and Oct. 1: Pinholes, their causes and prevention. Oct. 8: Effects of using metal previously subjected to corrosive conditions. Before Inst. Metals.

AMMONIA COMPRESSORS

AUTOMATIC CONTROL. Automatic Control for Synchronous Motor-Driven Ammonia Compressors, T. Mitchell. South Power Jl., vol. 49, no. 9, Sept. 1931, pp. 57–60, 3 figs. Brief historical review of developments in control of refrigerating systems; features of specific installations.

AUTOGIROS

DESIGN PROBLEMS. Design Problems of the Autogiro, W. L. LePage. Soc. Automotive Engrs.—Jl., vol. 29, no. 5, Nov. 1931, pp. 372–376 and (discussion) 376–378, 3 figs. Statics of dynamic balance, control of machine in flight and descent, control of rotor speed and of oscillation of rotor blades, design of suitable landing-gear, relation of rotor diameter to rate and angle of climb, and effect of weight on flight characteristics.

DEVELOPMENT. The Autogiro, As I See It, H. F. Pitcairn. Aviation, vol. 30, no. 11, Nov. 1931, pp. 630–632. Exchanges in development of autogiro; advantages with particular regard to angle of climb and ability to turn in short radii; ability of flying slowly and descending vertically.

AUTOMOBILES

CLUTCHES. Transmission Requiring Very Little or No Manual Shifting Is Seen as the Next Logical Development, A. F. Denham. Automotive Industries, vol. 65, no. 17, Oct. 24, 1931, pp. 644–646 and 670. Advantages possessed by vacuum-operated clutch over mechanical type of free wheeling are simplicity of lock-out mechanism and protection against engine stalling; centrifugal clutch for use on cars equipped with free wheeling.

DESIGN. Progress of Design. Autocar, vol. 67, no. 1877, Oct. 23, 1931, pp. 774–781, 4 figs. Progress during past year and developments that may be expected in future, with particular regard to engines, lubrication, electrical equipment, suspension system, transmission, etc.

MANUFACTURE. Die Rationalisierung der Lackierverfahren des Automobilbaues der Adlerwerke (Rationalization of Lacquering Procedure at Adler Automobile Works), E. Jurthe. Automobiltechnische Zeit., vol. 34, no. 27, Sept. 30, 1931, pp. 601-604, 7 figs. Operation and equipment in application of nitrocellulose lacquer by dipping method; specification of cost for different parts to which enamel has been applied manually or by dipping.

Einiges aus der mechanischen Oberflaechenbehandlung im Automobilbau (Mechanical Surface Treatment in Automobile Construction), G. Prachtl. Automobiltechnische Zeit., vol. 34, nos. 26, 27, and 28, Sept. 20, 1931, pp. 575-577, Sept. 30, pp. 610-611, and Oct. 10, pp. 634-636, 24 figs. Advantages of different cleaning methods for casting; pickling and enameling practice; heat treatment and surface hardening with particular regard to nitridation.

Reducing Costs With Automatic Jigs. Machy. (Lond.), vol. 39, no. 991, Oct. 8, 1931, pp. 33-37, 12 figs. Economies in labor and loading time effected by use of jigs and fixtures that automatically locate and clamp work in plants of Graham-Paige Motors Corporation; methods used in locating cylinders automatically in jigs; clamping and locating in combination with feeding table; tilting machine table.

The Manchester Works of the Ford Motor Co., Ltd. Automobile Engr., vol. 21, no. 285, Oct. 1931, pp. 393-398, 16 figs. Welding jigs employed in assembly of bodies; painting operations; machining operations on connecting rods, bearing caps, valve-spring washers, and differential housing; method of training apprentices.

STREAMLINE. The Tear-Drop Car, W. T. Fishleigh. Soc. Automotive Engrs.—Jl., vol. 29, no. 5, Nov. 1931, pp. 353-358 and (discussion) 359-362, 13 figs. Automobile is developed which has remarkable possibilities in matters of decreased wind resistance, fuel economy, riding comfort, and clear vision, in addition to striking beauty and grace; results of wind-tunnel tests upon models of this design and of conventional sedan.

TRACKLAYING. Citroen Builds Special Cars of the Tracklayer Type for Trans-Asiatic Expedition, of G.-M. Haardt. Automotive Industries, vol. 65, no. 17, Oct. 24, 1931, pp. 648-651, 7 figs. Design of automobile and tractor combination Citroen-Kegresse; running band made up of metal plates protecting transmission belt; contact with soil through succession of heavy rubber blocks; mountain-type cars equipped with supercharged 4-cylinder engine.

AUTOMOTIVE FUELS

DETONATION. Sur la détermination par la méthode photographique de la résistance des essences à la détonation (Photographic Method of Determining Resistance of Gasoline to Detonation), M. Aubert and R. Duchene. Académie des Sciences—Comptes Rendus, vol. 192, no. 25, June 22, 1931, pp. 1633-1635. Photographs showing flame propagation through fuel-air mixture under 7:1 compression; temperature is raised slowly until flame propagation becomes instantaneous.

B

BEARING METALS

BRONZE. Oxidation—A Cause of Porosity in Leaded Bronze, E. Doughty. Metals and Alloys, vol. 2, no. 4, Oct. 1931, pp. 181-183, 1 fig. Beneficial effect of zinc and phosphorus in small quantities; experiments show that oxidized metal with use of dry sand cores produced porosity specific gravities of some high lead alloys and lead oxides.

MANUFACTURE. Die Lagermetalle (Bearing Metals), G. Krebs. Zeit. fuer die Gesamte Giessereipraxis, vol. 52, no. 36, Sept. 6, 1931, (Metall) pp. 91-92. Precautions to be observed in manufacture; bronze bearings; advantages of tin bronzes for bearings subjected to heavy frictional pressure, composition of good bearings for this purpose.

BEARINGS

JOURNAL—LUBRICATION. Einfluss des Lagerspieles auf die Tragfaehigkeit und den Reibungsverbrauch von Gleitlagern (Influence of Play of Bearings on Bearing Capacity and Friction of Journal Bearings), E. Falz. Petroleum, vol. 27, no. 41, Oct. 1931 (supp.) pp. 1-3. Hydrodynamic significance of defined bearing play; designation of ideal bearing play.

BOILER FEEDWATER

HEATERS. Completely Deaerates and Heats Water to Temperature of 150 lb. Steam, L. N. Scharnberg. South. Power Jl., vol. 49, no. 10, Oct. 1931, pp. 30-32, 3 figs. Open deaerating heater takes steam direct from turbine exhaust and heats water to saturated temperature of this steam; complete removal of free carbon dioxide and dissolved oxygen, seriously corrosive at high temperatures of plant, effected by use; sectional views of heater.

TREATMENT. The Use of Phosphate in Boiler Water Conditioning, F. J. Mathews. World Power, vol. 16, no. 94, Oct. 1931, pp. 307-308 and 311-312, 1 fig. Treatment of boiler water to prevent scale formation; general conclusion is that in order to prevent adherent scale formation on boiler surfaces, it is only necessary to adjust ratio of requisite acidic ions so that throughout whole period of evaporation solubility products of substances of positive temperature coefficients will always be reached before solubility products of substances with negative temperature coefficients. Bibliography.

La distillation et le dégazage des eaux d'alimentation des générateurs à vapeur (Distillation and Degassing of Boiler Feedwater), J. M. Helvé. Revue Industrielle, vol. 61, nos. 2267 and 2268, Oct. 1931, pp. 568-569, and Nov., pp. 633-637, 11 figs. Diagram of installation and details of feedwater heater of Wier; twin evaporizer distilling 6 tons of water per hour; Kestner evaporizer; various degassing equipment and its principal characteristics; complete diagram of distillation and degassing installation.

BOILERS

CONTROL. Die genaue Temperaturmessung von Kesselrauchgasen mit Absaugepyrometern (Accurate Temperature Measurement of Boiler Flue Gases With Suction Pyrometers), H. Friedrich. Mitteilungen aus den Forschungsanstalten, vol. 1, no. 6, July 1931, pp. 139-146, 9 figs. Design and application of pyrometer for measurement of temperatures from 600 to 1300 deg. cent.; results of temperature measurements in boiler.

L'installation de controle thermique de la centrale "Gersteinwerk" (Temperature Control of the "Gerstein" Power Plant), Barrère. Technique Moderne, vol. 23, no. 19, Oct. 1, 1931, pp. 652-661, 15 figs. Complete electric-control equipment at plant of Vereinigte Elektrizitaetswerke Westfalen A. G. in Dortmund, operating with four boilers of 60 tons each; steam pressure 22 atm. of 410 deg. cent.

CORROSION. Hat der Sauerstoffgehalt des Wassers einen Einfluss auf die Wassersteinbildung? (Has Oxygen Content of Water Any Effect on Boiler-Scale Formation?), W. Heckmann. Gesundheits-Ingenieur, vol. 54, no. 30, July 25, 1931, pp. 459-463, 2 figs. Tests of hot-water systems; equilibrium between free and combined carbon dioxide; corrosion in water containing oxygen and in water free of oxygen; experiments on formation of boiler scale in water free of oxygen. Bibliography.

Waermeleitfaehigkeit von Kristallinen Kesselsteinen (Heat Conductivity of Crystalline Boiler Scale), P. Zarnitz. Waerme, vol. 54, no. 41, Oct. 10, 1931, pp. 756-761, 10 figs. Investigations show that coefficient of conductivity of crystalline scale, in contrast to amorphous substances, is not dependent on volumetric weight, but only on crystalline texture; heat-conductivity coefficients of coarse crystalline boiler scale are much higher than those of amorphous deposits.

DESIGN. Steam Generation Unit, H. Kreisinger. Power Plant Eng., vol. 35, no. 21, Nov. 1, 1931, pp. 1053-1055, 4 figs. Design in which furnace, convection surface, superheater, and air heating are related for best economy, installed at Solvay Process Co.'s plant; sectional diagrams of boiler; curves of heat absorption and heating surface in various sections of unit.

FIRING. Elastizitaet von Steinkohlenfeuerungen (Flexibility of Bituminous-Coal-Fired Furnaces), F. Schulte and H. Presser. Archiv fuer Waermewirtschaft, vol. 12, no. 10, Oct. 1931, pp. 281-289, 14 figs. Results of tests; as coefficient of elasticity, time in seconds required for doubling initial output of boiler plant was determined; influence of experimental results on problem of storage.

Stand U. Entwicklungsziele der modernen Steinkohlenfeuerungstechnik (Status and Aims of Modern Bituminous Coal-Firing Technology) W. Kretschmer. Internationale Bergwirtschaft und Bergtechnik, vol. 24, no. 15, 1931, pp. 211-215, 8 figs. Smokeless furnaces; pulverized-coal firing.

FURNACES, AIR-COOLED. Der Aufbau luftgekuehlter Feuerraumwaende (Construction of Air-Cooled Furnace Walls), Harraeus. Feuerungstechnik, vol. 19, no. 10, Oct. 15, 1931, pp. 154-156, 6 figs. Review of development: loose shoring of inner on outer wall; tying by means of anchor chains; design of wall corners; arrangement of inner wall in wall layers; separate tying of wall brick; cooling-water tubes in air duct.

HIGH-PRESSURE. Considérations sur la Chaudière Loëffler à haute pression au point de vue de la construction (Loeffler High-Pressure Boiler From Design Viewpoint), Rochel. Chaleur et Industrie, vol. 12, no. 137, Sept. 1931, pp. 451-458, 13 figs. Principles of operation; thermal efficiency, steam circulation pump; superheating; Loeffler boiler of 40 tons capacity operating in mine described and illustrated in detail.

OPERATION—FRANCE. Boilers at Gennevilliers Power Station. Engineer, vol. 152, no. 3954, Oct. 23, 1931, pp. 429-434, 23 figs. Account of boiler equipment at start, and of alterations and additions made to it subsequently; reconditioning original Babcock and Stirling boilers; pulverized fuel; Ladd-Belleville boilers; removing dust from gases. Based on article previously indexed from Génie Civil, Sept. 26, 1931.

STEAM-HEATING, OIL-FIRED. Study of Oil-Fired Heating Boilers, R. C. Cross and W. R. Lyman. Heat. and Vent., vol. 28, no. 10, Oct. 1931, pp. 45-49, 15 figs. Elementary features of oil-burner design and operation; boiler-furnace design and effect upon oil operation; curves illustrating variations in burner and boiler operation.

WATER-TUBE. Deux ans de marche industrielle de deux chaudières R. L. à ailettes (Two Years' Industrial Operation of Two Type R. L. Boilers With Ribbed Tubes), E. Rauber. Chaleur et Industrie, vol. 12, no. 136, Aug. 1931, pp. 406-410, 1 fig. Observations on two Babcock & Wilcox boilers of French make installed in electric power plant; steam pressure 15 kg. per sq. cm.; superheated-steam temperature, 350-375 deg. cent.; operating results and analysis.

Die Berechnung des Wasserumlaufes in Kesselrohrbuendeln, etc. (Calculation of Water Circulation in Boiler-Tube Nests and Its Bearing on Design of Water-Tube Boilers), H. Seidel. Zeit. des Bayerischen Revisions-Vereins, vol. 35, nos. 17, 18, and 19, Sept. 15, 1931, pp. 211-216, Sept. 30, pp. 225-231, and Oct. 15, pp. 240-242, 28 figs. Calculation of speed of circulation; pressure in boiler; circulation diagram; calculation of loss; influence of flue-gas circulation on water cycle; conclusions.

Une étude d'ensemble sur la résistance des materiaux à employer dans la construction des chaudlières—I (Study of Resistivity of Materials to Be Used in Boiler Construction), G. Paris. Chaleur et Industrie, vol. 12, no. 138, Oct. 1931, pp. 507-516, 26 figs. Hazards from tubes in water-tube boilers during operation.

BOLTS AND NUTS

MANUFACTURE. Bolt and Nut Works of Messrs. British Dardelet Threadlock, Limited. Engineering, vol. 132, no. 3432, Oct. 23, 1931, pp. 535-536, 2 figs. Factory located in London is divided into four main departments, devoted to production of hot-forged bolts, cold-headed and high-tensile bolts, bright-steel bolts and Atkins socket screws, respectively; works include laboratory for testing all raw materials and equipped with machines for tensile, vibration, impact, and Brinell tests, as well as with optical-projection apparatus for examining threads.

Bolts, Screws & Nuts, Materials and Manufacture. Metal Progress, vol. 20, no. 5, Nov. 1931, pp. 66-68, 1 fig. Trade classification of bolts most frequently used, together with steels; tabulation of chemical analysis; roll threading machine at Russell, Burdsall & Ward Bolt & Nut Co. plant; cold heading; hot heading; trimming; burnishing; shaving and pointing; tentative recommended practice by Recommended Practice Committee, A.S.S.T.

Heat Treatment of Bolts and Nuts, F. O. Kichline. Iron Age, vol. 128, no. 17, Oct. 22, 1931, pp. 1058-1060, 3 figs.; see also Steel, vol. 89, no. 18, Oct. 26, 1931, pp. 31-33 and 38, 4 figs. Required characteristics of bolts in modern usage; manufacturing procedure and equipment at Lebanon plant of Bethlehem Steel Co., with particular regard to operation of automatic-type electric heat-treating furnaces; tabulated data on strength properties of alloy steel.

BORING MACHINES

DIAMOND BORING—FIXTURES FOR. Hydraulic Type Fixtures Speed Up Diamond Boring, C. A. Birkebak. Machy. (N. Y.), vol. 38, no. 2, Oct. 1931, pp. 112-114, 5 figs. Fixtures to insure rigidity and precise location essential in boring to close tolerances, designed by Ex-Cell-O Aircraft & Tool Corp., for use with either diamond or tungsten-carbide tools.

BRASS

MANGANESE-NICKEL. Sur un mode simplifié de fabrication des laitons spéciaux (Simplified Process of Manufacturing Special Brasses), A. Le Thomas. Revue de Métallurgie, vol. 28, no. 9, Sept. 1931, pp. 518-523, 11 figs. Technical uses of special brasses; difficulties involved in manufacture; suitable alloying elements;

deals specially with brass containing 5 per cent nickel, and 3 per cent manganese.

BROACHING

FIXTURES. Broaches for Internal and External Use Play a Very Important Part in Precision Work at Automotive Plants, J. R. Wells. Automotive Industries, vol. 65, no. 19, Nov. 7, 1931, pp. 728–731, 9 figs. Properly designed holding fixtures and loading methods simplified to increase production and permit many parts formerly milled to be surface broached; output and tolerances.

C

CABLEWAYS

MOVABLE DUMPING FRAME. Aerial Ropeway With Movable Dumping Frame. Engineering, vol. 132, no. 3432, Oct. 23, 1931, pp. 521–523, 12 figs. partly on p. 526. Installation constructed by R. White & Sons for disposal of refuse and marl; return terminal, provided with extension 6 ft. long, mounted at required angle constitutes first length of dumping frame to which further lengths are added as required; ropeway between loading terminal and dumping site is 1500 ft. long, carried on standards 25–30 ft. high.

CARS

ELECTRIC-RAILROAD—DESIGN. Stream Lines for Speed. Traction Shop and Roadway, vol. 4, no. 10, Oct. 1931, pp. 289–291, 5 figs. To meet competition in suburban areas, Philadelphia and Western designs and builds streamlined third-rail cars for high-speed operation at reduced power consumption and maintenance costs; floor plan of new streamlined car, showing lengths, widths, and arrangement of seats.

FREIGHT—HOPPER. Pullman Produces Welded Hopper Cars. Welding Engr., vol. 16, no. 9, Sept. 1931, pp. 52–53 and 69, 6 figs. Specifications and procedure in making car from pressed shapes by gas and electric arc welding; riveted hoppers have light weight of 52,700 lb., while all-welded car has light weight of 45,900 lb.

PASSENGER—AIR CONDITIONING. Air Cooled Passenger Railway Cars in France. Ice and Refrig., vol. 81, no. 5, Nov. 1931, pp. 277–280, 8 figs. Features of cooled passenger car operating on Paris-Orleans Railroad; problems which had to be solved to increase comfort of passengers; apparatus used on coach shown at exposition; specifications of cooling device; analysis of results obtained on test run.

Cooling Railway Cars With Steam. Heat and Vent., vol. 28, no. 10, Oct. 1931, pp. 75–76, 3 figs. Features of novel method of cooling railway passenger cars by using steam from locomotive was demonstrated recently in specially constructed laboratory at Carrier plant in Newark; schematic arrangement of cooling system.

Experimental Air-Cooled Pullmans Show Travel Possibilities. Ice and Refrig., vol. 81, no. 5, Nov. 1931, pp. 281–282, 1 fig. Air-cooled pullman cars now undergoing actual tests on railroads; comparison of temperatures inside and outside; combined heating and cooling system; problems concern mostly economic side of question; necessity of overcoming mechanical obstacles.

New Car Conditioning System Uses Ice, R. T. Brizzolara. Refrig. Eng., vol. 22, no. 4, Oct. 1931, pp. 240–244. Basis requirements studied and met by special plans; ice and its essential equipment for air conditioning; refrigerating-equipment space requirements; outline of air circulating system; operating test data.

Pennsylvania Railroad Co. Cools Passenger Trains With Ice, S. Freer and F. I. McCandlish. Ice and Refrig., vol. 81, no. 4, Oct. 1931, pp. 215–219, 8 figs. Actual tests conducted on ice cooling system indicate that development is both practical and desirable; adoption followed detailed investigation; comfort conditions obtained with noise and dirt eliminated; five diners have continuous cooled-air circulation; pullman sleeping cars precooled in hot weather.

REFRIGERATOR. Freight Refrigerator Cars, Canadian Pacific Railway. Can. Ry. and Mar. World, vol. 403, Sept. 1931, pp. 561–562, 4 figs. Design and constructional details of cars constructed by National Steel Car Corp.; diagrams illustrating insulation details.

The Flettner Rotor Cooling System for Refrigerating Vans. Ry. Gaz., vol. 55, no. 16, Oct. 16, 1931, p. 502, 2 figs. Design and operating characteristics of system by which air currents produced by forward movement of vehicle are utilized to circulate cold air inside car; details of Flettner-rotor cooling system as applied to railway refrigerator cars.

CAST IRON

HIGH-TEST. Hochwertiger Grauguss (High-Test Gray Cost Iron), L. Treuheit. Zeit. fuer die Gesamte Giessereipraxis, vol. 52, nos. 37 and 38, Sept. 13, 1931, pp. 309–310 and Sept. 20, pp. 321–322. Properties required of high-grade cast iron; addition of steel according to Emmel process; Corsalli method of improving cast iron; Krupp process; advantages of application of alloying element, especially so-called E. K. and H. W. packages; heat treatment; Lanz and Schuez processes; formation of pearlitic structure.

MOLTEN, SPECIFIC VOLUME OF. Das spezifische Volumen von fluessigem Eisen (Specific Volume of Molten Iron), E. Widawski and F. Saurwald. Stahl und Eisen, vol. 51, no. 42, Oct. 15, 1931, pp. 1290–1291, 5 figs. New device for density measurements of molten metals suitable for maximum temperatures; results of measurements, specific volume of iron-carbon alloys at melting point and at 1600 deg. cent.

MOLYBDENUM CONTENT. Mechanical and Creep Properties of Molybdenum Cast Iron, C. H. Loring and F. B. Dahle. Metals and Alloys, vol. 2, no. 4, Oct. 1931, pp. 229–235 13 figs. Microphotographs comparing form of graphite particles in cast irons with and without molybdenum; graphs illustrate Brinell hardness of three series of nickel-molybdenum cast irons; modulus of rupture and tensile strength of various classes of molybdenum cast iron; transformation temperatures of cast iron containing molybdenum; mechanical properties of molybdenum cast iron at room and elevated temperatures; molybdenum iron is not inferior in machinability.

TESTING. Charactérisation des propriétés mécaniques des piéces moulées en fonte grise (Mechanical Properties of Molded Cast-Iron Specimens), A. Portevin. Int. Congress Testing Matls.—Advance Paper, 1931, 17 pp., 3 figs. After referring to report submitted to Congress at Amsterdam, Sept. 1927, author enumerates principles determining choice of methods and conditions of application of tests, principles governing determination of method of testing, selection of testpieces, form and dimensions of pieces; improvements in modern methods of testing castings; conclusions to be deduced from study of old and new test methods.

CHROMIUM-NICKEL STEEL

WELDING. Riveted and Welded Structures of the Rustless Steels, T. H. Nelson. Iron Age, vol. 128, no. 17, Oct. 22, 1931, pp. 1054–1057, 5 figs. Effect of welding on carbide precipitation; microphotograph illustrates areas impoverished of chromium at crystal boundaries; titanium content of 0.50 per cent or 1.00 per cent of vanadium upward has beneficial effect on retarding carbide precipitation and subsequent corrosive attack.

Welding Chrome Nickel Alloys, J. G. Norris. Welding Engr., vol. 16, no. 9 Sept. 1931, pp. 46–47, 5 figs. Technique of application which must be followed in order to get satisfactory results; set-up for butt welding and corner welding of stainless-steel sheets; table showing current adjustments found to be most satisfactory for different thicknesses.

CHROMIUM STEEL

HIGH-CHROMIUM STEELS. High Chromium Steels, A. Westgren. Metal Progress, vol. 20, no. 5, Nov. 1931, pp. 57–61, 10 figs. Interpretation of principal research by means of X-ray metallography to determine constitution; ternary equilibrium diagrams; double carbides in ball-bearing steels.

COAL CARBONIZATION

LOW-TEMPERATURE. Low-Temperature Fuel Production. Power Eng., vol. 26, no. 307, Oct. 1931, pp. 371–375, 6 figs. Features of Davidson rotary carbonizing system, as applied to production of semi-coke for domestic and boiler firing, and also special grate developed for burning of slacks of any description; blending in rotary and static reports; influence of coals and of low carbonizing temperatures; grate for burning fines.

COILING MACHINES

RING—FLAT STRIP. Ring Coiling Machine. Engineering, vol. 132, no. 3429, Oct. 2, 1931, p. 450. Machine constructed for River Rouge Plant of Ford Motor Co., is used for coiling flat strip, $^3/_8$ by 1 in., edgewise into rings, 14 in. in external diam.; this strip is made of tough alloy steel, known as Maxel, and rings, when finished, form blanks for flywheel ring starting gear used on all Ford motors in model A and AA chassis.

CONVEYORS

POWER REQUIREMENTS. Determining the Driving Power of Conveyors, C. H. Walsh. South Power Jl., vol. 49, no. 9, Sept. 1931, p. 73, 1 fig. Design and operating features of strain dynamometer for determining driving requirements of each conveyor in change-over from belt drive to individual electric drive.

COPPER-SILICON ALLOYS

WELDING. Large Welded Everdur Pressure Vessels, M. Powell and I. T. Hook. Am. Welding Soc.—Jl., vol. 10, no. 9, Sept. 1931, pp. 39–47, 26 figs. Investigation of possible welding procedure by series of tests on $^1/_2$-in. plate; micro photograph illustrates effect on structure of cold working and annealing; methods of constructing 500-gal. storage heater and 10,000-gal. accumulator by electric arc welding.

CRANES

ELECTRIC. New Type Crane and Hoist, G. A. Caldwell. Elec. World, vol. 98, no. 16, Oct. 17, 1931, pp. 692–695, 6 figs. Motor-generator set used as exciter for main alternating-current crane or hoist motor to give dynamic control in lowering operations; principles used and description of application; practice illustrated on Brooklyn installation; speed-torque characteristics are given in curves.

TYPES. Enquete sur l'état actuel de la technique des appareils de levage et de manutontion mecanique (Investigation of Present State of Devices for Mechanical Lifting and Handling), M. Pelou. Science et Industrie, vol. 15, nos. 212 and 213, Sept. 1931, pp. 435–444 and Oct. 1931, pp. 478–490, 44 figs. Goliath, traveling, gantry and semi-gantry cranes; special types of traveling cranes utilized in metallurgical industries.

CUTTING TOOLS

TUNGSTEN CARBIDE. Proper Grinding Practice Assures Success of Tungsten-Carbide Tools, C. Sellers, 3rd. Automotive Industries, vol. 65, no. 16, Oct. 17, 1931, pp. 586–589, 5 figs. Table showing variation in grain and grade of wheel used; 12 firms represented; angles of rake and clearance; method of holding tools while grinding; Sellers machine grinds on periphery of wheel and has quick method of setting tool.

The Use of Tungsten-Carbide Tools Results in Holding More Uniform Limits on Machined Parts, J. E. Wells. Automotive Industries, vo. 65, no. 16, Oct. 17, 1931, pp. 574–577, 4 figs. Boring cast-iron transmission cases; machining fly wheels in Marmon Motor Car Co., Indianapolis plant; boring cast-iron shock-absorber bodies; machining aluminum pistons; machining carburetor bodies; machining brake drums; feeds, speeds, and tolerances for different operations on cylinder block.

CYLINDERS

THICK-WALLED—DESIGN. Curves Aid in Design of Thick-Walled Tubes and Cylinders, F. E. Wertheim. Heat., Piping, and Air Conditioning, vol. 3, no. 10, Oct. 1931, pp. 850–851, 2 figs. Methods of using curves and specific examples showing use of curves in design of thick-walled tubes and cylinders with minimum computation.

D

DIES

FORMING. High-Speed Die for Multi-Slide Machine—II, F. C. Duston. Machy. (N. Y.), vol. 38, no. 2, Oct. 1931, pp. 102–105, 4 figs. Design and operation of set of tools that pierced, blanked, and formed 3,000,000 pieces at rate of 125 per min. from "$^1/_4$ hard" coiled brass stock, $^5/_{16}$ in. wide by 0.020 in. thick.

PUNCHING. A Cutting-Off Die for Heavy Wide Stock, C. W. Hinman. Am. Mach., vol. 75, no. 17, Oct. 22, 1931, p. 631, 1 fig. Press tools used for perforating and cutting off sheet-steel stock in strips $2^1/_4$ in. wide and in lengths of 32 in.; material is $^1/_8$ in. thick and is cut from sheets 32 in. wide.

SHEET-METAL FORMING. Dies for Producing Sheet-Metal Wheels. Machy. (Lond.), vol. 39, no. 993, Oct. 22, 1931, pp. 118–119, 7 figs. Designs suitable for work requiring drawing, reversing, pinching, and edging operations.

DIESEL-ELECTRIC POWER PLANTS

SWITZERLAND. L'extension de la centrale thermique de secours de la Ville de Genève, etc. (Extension of Stand-by Power Plant of City of Geneva by Installation of Two A. C. Diesel Generator Sets of 3000 Hp. Each). Bulletin Technique de la Suisse Romande, vol. 57, nos. 2 and 3, Jan. 24, 1931, pp. 17–21 and Feb. 7, pp. 29–32, 13 figs. Two 4-cylinder, 2-cycle Sulzer engines; supercharging arrangements;

2-phase a.c. alternators, 7000 volts, 50 cycles at 125 r.p.m.; graph and tables of operating characteristics.

TORSIONAL VIBRATIONS. Torsional Vibration in the Diesel-Electric Set, C. H. Bradbury. Instn. Electric Engrs.—Jl., vol. 69, no. 418, Oct. 1931, pp. 1295–1302, 12 figs. General methods of determining natural frequences of simple systems; method of reducing Diesel engine and generator to system suitable for calculation; examination is made of modes of vibration most commonly encountered in practice and method of discriminating between major and minor critical speeds; damper and torsiograph are described; actual examples of sets in which torsional resonance has been encountered.

VERNON, CALIF. The Large Oil Engine for Central Station Service, O. F. Allen. Power, vol. 74, no. 17, Oct. 27, 1931, pp. 596–599, 4 figs. Recent purchase of five 7000-hp. double-acting two-cycle Diesel engines for Vernon, Calif., municipal plant; engines embrace well-proved features and represent modern stage in long period of development which started with Diesel's first crude machine; features of specific installations.

DIESEL ENGINES

AIR FILTERS. Need for Clean Air in the Diesel, O. Adams. South. Power Jl., vol. 49, no. 10, Oct. 1931, pp. 41–43, 3 figs. Even with unusually clean normal air, amount of dust and grit carried by it into Diesel engine is serious obstacle to economical maintenance and operation; principles of air filters; technical information.

AUTOMOTIVE. New Type of High-Speed Heavy-Oil Engine, S. J. Davies. Engineer, vol. 152, no. 3953, Oct. 16, 1931, pp. 414–417, 12 figs. Results of test carried out by author on "Omo" engine at Oberhaensli Works, Bregenz, Austria; distinguishing features are hollow bowl-shaped hot body, which serves as reservoir of heat in combustion chamber, and method by which suitable motion is given to air entering spherical chamber; from tests on three similar engines with bores 70 mm., 110 mm., and 130 mm., it would appear that within ranges of speed investigated, neither speed of revolution nor rapidity of combustion imposes limits to engines of this design.

AUXILIARY POWER. Diesel as an Auxiliary to Central Power Systems—III, O. F. Allen. Power, vol. 74, no. 19, Nov. 10, 1931, pp. 670–673, 5 figs. One of most attractive phases of oil-engine application is use as auxiliary power to central power systems; Diesel may serve as peak-load carrier, as generating unit at end of transmission system, or as protection against service interruption in industrial plant or office building.

FUEL INJECTION. Neuere amerikanische und deutsche Untersuchungen ueber Druckeinspritzung bei Dieselmotoren (Recent American and German Investigations of Solid Injection in Diesel Engines), F. Sass. Forschung auf dem Gebiete des Ingenieurwesens, vol. 2, no. 10, Oct. 1931, pp. 351–358, 13 figs. Flow through nozzle; formula of velocity; influence of viscosity and velocity; importance of accurate nozzle bores; distortion of injection characteristic due to elasticity of needle-valve stem; penetration of fuel spray; expansion of spray; multiplex indicator.

Penetration and Duration of Fuel Sprays From a Pump Injection System, A. M. Rothrock and E. T. Marsh. Nat. Advisory Committee Aeronautics—Tech. Notes, no. 395, Oct. 1931, 16 pp., 23 figs. on supp. plates. Method and equipment of taking high-speed motion pictures of individual fuel sprays from pump injection system; changes in spray-tip penetration with changes in pump speed, injection-valve opening and closing pressures, discharge-orifice area, injection-tube length and diameter, and pump throttle setting, with and without check valve; effects of variables on time lag and duration of injection determined with oscilloscope.

E

ELECTRIC WELDING, ARC

OIL INDUSTRY. Developments in Arc Welding as Applied to Oil Industry, J. C. Lincoln. Oil Weekly, vol. 63, no. 5, Oct. 16, 1931, pp. 18–24, 18 figs. Application of shielded-arc process to welding of pipe lines, oil tanks, vaporizer tubes, and other forms of refinery equipment. Before Am. Petroleum Inst.

UNITED STATES, PRACTICE IN. Eindruecke auf dem Gebiete der Schweisstechnik aus den Vereinigten Staaten von Amerika (Impressions of Welding Practice in the United States of America), H. Lottmann. V.D.I. Zeit., vol. 75, no. 41, Oct. 10, 1931, pp. 1265–1269, 16 figs. Review of arc-welding practice in United States; American types of automatic welding equipment; features of reservoir and boiler welding, use of welding in shipbuilding; types of electrodes and their uses; progress in aluminum welding; special reference is made to work of A. O. Smith Corp. of Milwaukee, Wis.

ELEVATORS, ELECTRIC

CONTROL. Pliotron Tubes Level Elevators in McGraw-Hill Building. Power, vol. 74, no. 18, Nov. 3, 1931, pp. 632–635, 7 figs. In new 33-story McGraw-Hill Building there are nine passenger and five freight elevators, which are equipped with pliotron leveling devices; five express passenger elevators have automatic push-button control, and four locals are car-switch-operated; elementary connection diagram of pliotron elevator-control system.

DOOR OPERATION. How Hoistway Door Operation Affects Elevator Service, H. B. Cook. Power, vol. 74, no. 17, Oct. 1931, pp. 608–609, 2 figs. Method for determining force necessary for opening and closing different types of elevator hoistway doors and what effect increasing time of operation has on door mechanism; charts for calculating weight of elevator hoisting doors and force and time required.

ENERGY

STORAGE. Stored Energy, J. Frith and F. Buckingham. Manchester Assn. Engrs.—Trans., 1930–1931, pp. 13–28 and (discussion) 28–34, 3 figs. Chronological review of stored energy; modern design features of power plants and plant interconnection.

F

FLOW OF WATER

IMPACT. On the Loss of Energy at Impact of Two Confined Streams of Water, I. Naramoto and T. Kasai. Kyushu Imperial Univ.—College of Eng.—Memoirs, vol. 6, no. 3, 1931, pp. 189–261, 40 figs. Theory of impact of two confined streams; results of experiments on impact of streams confined in wooden pipes; friction loss; method of calculation of loss of energy; loss at elbows with dead end; loss at plain elbows; results of these experiments differ from Gibson's. (In English.)

ORIFICES, DISCHARGE THROUGH. Constant Flow Characteristic of the Plane Orifice in Proximity to Side Walls, C. W. Harris. Univ. Wash.—Eng. Experiment Station Series—Bul., no. 56, July 1, 1931, 18 pp., 5 figs. Laboratory studies of case of partially closed gate with bottom of opening flush with floor of flume; opening was square and placed in square box with area of cross section 36 times area of opening; comparison of central location with location against side wall; there is no marked difference in discharge of rectangular orifice, whether it be located centrally or so as to touch one of walls, provided wall projects outward beyond inner face of orifice plate sufficiently to furnish lateral support for jet.

FOUNDRY PRACTICE

CENTRIFUGAL CASTING. Centrifugal Casting of Metals and Alloys, J. E. Hurst. Metals and Alloys, vol. 2, no. 4, Oct. 1931, pp. 197–205, 16 figs. Difference in process of solidification between vertical sand castings and centrifugal castings; crystal structure and properties of bronze, monel metal, cast iron and steel in industrial applications of centrifugal casting; properties of hardened and tempered liners; diagram showing distribution of constituents across radial thickness of centrifugally cast-iron pipes.

MOLDING—TIME STUDY. Scientific Rate Setting Predetermines Costs, T. M. Harrison. Foundry, vol. 59, no. 20, Oct. 15, 1931, pp. 37–38. Establishment of time of various fundamental operations and determination of those which go to make up elements of any particular job, especially floor molding. Before Am. Foundrymen's Assn.

FURNACES, ANNEALING

NORMALIZING. Normalising of Sheet Steel in Great Britain, E. S. Lawrence. Sheet Metal Industries, vol. 5, no. 5, Sept. 1931, pp. 327–329, 3 figs. Continuous heat-treating or normalizing furnaces as utilized to obtain extra-deep drawing properties desired in thin-gage sheet steels used for motor-car bodies; emphasizes attention given to this type of furnace especially by sheet mills of Great Britain and Wales.

FURNACES, MELTING

PULVERIZED-COAL. Tiegelloser kippbarer Metall-Schmelzofen mit Kohlenstaubfeuerung (Pulverized-Coal Tilting Furnaces Without Crucible for Melting Non-Ferrous Metals), O. Bechmann. Zeit fuer die Gesamte Giessereipraxis, vol. 52, nos. 37 and 39, Sept. 13, 1931, (Metall) pp. 93–94, and Sept. 27, pp. 97–98, 6 figs. In new design according to Reimeister system, long path of flame is intercepted and problem of combustion of pulverized coal in small space is solved.

FUELS

GREAT BRITAIN. Coal: Smokeless Fuel and Oil From National Standpoint, W. R. Ormandy. Inst. Fuel—Jl., vol. 5, no. 19, Oct. 1931, pp. 56–77, 3 figs.; see also Colliery Guardian, vol. 143, nos. 3693 and 3694, Oct. 9, 1931, pp. 1210–1213, and Oct. 16, pp. 1292–1294, and (discussion) 1294–1296; Iron and Coal Trades Rev., vol. 123, nos. 3319, 3320, and 3321, Oct. 9, 1931, p. 542, and (discussion) Oct. 16, p. 582, and Oct. 23, p. 623; and Gas Jl., vol. 196, no. 3569, Oct. 14, 1931, pp. 140–144. Coal; mineral oil; oil from coal; hydrogenation; destructive distillation of coal; gas industry; household smokeless fuel; low-temperature carbonization; research.

G

GAS PRODUCERS

LIGNITE. Krafterzeugung aus Braunkohle in Sauggasanlagen (Power Generation From Lignite in Suction Gas Plants), W. Kirnich. Braunkohle, vol. 30, no. 41, Oct. 10, 1931, pp. 889–893, 3 figs. Of two groups of plants, namely, those for tar recovery and those for tar combustion or conversion, only latter is discussed; types of producers; economic and technical advantages of suction-gas plants for lignite; data on gas composition and profitability of plants.

METALLURGICAL. Wider Use for Slagging Producer, N. E. Rambush and F. F. Rixon. Chem Age, vol. 24, no. 641, Oct. 10, 1931, pp. 310–312. By employing hot blast, slagging producer acts as direct producer of metallurgical products, ferrous and non-ferrous, by virtue of smelting which takes place at hearth. Before Inst. Chem. Engrs.

GEARS

CASTINGS FOR. Wie vermeidet man die Lunkerbildung bei Zahnraedern (Prevention of Piping in Gears), G. Krebs. Zeit. fuer die Gesamte Giessereipraxis, vol. 52, no. 37, Sept. 13, 1931, pp. 311–312. Recommendation for casting gears for heavy machines, presses, shears, etc.; composition of burden.

DESIGN. A New Module System. Machy. (Lond.), vol. 39, no. 991, Oct. 8, 1931, pp. 45–46. Modules selected so as to give range whose steps from pitch to pitch are commensurate with those of diametral pitches, metric modules, and circular pitches; so good is approximation of modules to circular pitches that circular-pitch gears can be cut with "new module" disk cutters; table covers all circular pitches with corresponding modules from $^1/_{16}$ to 6 in.

Wenschelijke en bereikbare Nauwkeurigheid in de hedendaagsche Tandradconstructie (Desirable and Attainable Accuracy in Present Gear Design), R. Van Cauteren. Union des Ingenieurs Sortis des Ecoles Speciales de Louvain—Bul., vol. 1, no. 1, 1931, pp. 27–46, 11 figs. General properties of tooth profile; maximum allowable error mathematically discussed and exemplified; extent to which theoretical exact design can be applied practically.

TIP RELIEF. Tip Relief and Cost Finding Discussed at Semi-Annual Meeting of American Gear Manufacturers Association, P. M. Heldt. Automotive Industries, vol. 65, no. 17, Oct. 24, 1931, pp. 640–642 and 656. Economic problems of gear industry; two degrees of tip relief; uniform cost accounting; standardized specifications; manganese range of case-hardening steel. Before Am. Gear Mfrs. Assn.

GRINDING MACHINES

CHUCKS. Magnetic Chucks Keep Pace With Modern Surface Grinders, F. L. Simmons. Iron Age, vol. 128, no. 18, Oct. 29, 1931, pp. 1114–1115 and 1138, 5 figs. Design of chucks with maximum of magnetic working area and greatest possible gripping power built by Taft-Pierce Mfg. Co.

GRINDING WHEELS

BALANCING. Should Grinding Wheels Be Balanced When They Are Wet? Grits and Grinds, vol. 22, no. 9, Sept. 1931, pp. 1–4, 4 figs.

Tests show that if wheel is balanced while wet and then operated in machine it will soon be out of balance, because upon rotating, part of water in wheel will be thrown out and balancing weight itself will then cause out-of-balance condition.

H

HEAT TRANSMISSION

RADIATION. Strahlungsaustausch zwischen den Oberflaechen zweier fester Koerper (Heat Exchange Through Radiation Between Surfaces of Two Solid Bodies), O. Seibert. Waerme, vol. 54, no. 40, Oct. 3, 1931, pp. 737–739, 1 fig. Heat exchange by radiation defined in its separate phases, and two most important values, effective radiation coefficient and coefficient of absorption of radiant heat are derived; geometrical explanation of latter.

VISCOUS FLOW. Heat Transfer to Liquids in Viscous Flow, T. B. Drew. Indus. and Eng. Chem., vol. 23, no. 10, Oct. 1931, pp. 1180–1181, 1 fig. Discussion of article by C. G. Kirkbridge and S. L. McCabe, previously indexed from June 1931, issue of same journal; it is claimed that theoretical integrated curve given by writers is too low and more accurate plot is offered. Reply by Kirkbridge and McCabe.

HYDRAULIC LABORATORIES

UNITED STATES. New Hydraulic Laboratory at University of Tennessee. Eng. News-Rec., vol. 107, no. 19, Nov. 5, 1931, pp. 724–725, 2 figs. Description of research laboratory of about 6200 sq. ft. floor space having canal 6 ft. wide, 6 ft. deep and 76 ft. long, equipped with centrifugal pump designed to discharge 5000 gal. per min. against head of 22 ft., or 2000 gal. against head of 36 ft.; surge tank is 5 ft. in diameter and 22 ft. high.

HYDRAULIC TURBINES

KAPLAN. Vargoen Power Station, Sweden. Engineer, vol. 152, no. 3854, Oct. 23, 1931, p. 434, 1 fig. Order has been placed by Swedish Royal Waterfall Board for two very large Kaplan turbines for power station on Gotha River with 4.3 m. head; station will be automatically controlled without any regular attendants; each of two turbines is being designed to develop 15,200 hp.; speed is 46.9 r.p.m. and runner will be 8000 mm. in diam.

PROPELLER-TYPE. Arbeitstroemung einer Propeller-turbine (Flow of Work in Propeller-type Turbine), F. Busmann. Forschungsheft 349, vol. 2, Oct. 1931, 24 pp., 76 figs. Most important factors governing existing propeller theories; braking tests on experimental turbine; results of velocity measurements; evaluation of results. Bibliography.

HYDROELECTRIC POWER PLANTS

CALIFORNIA. Mokelumne River Development. Power Plant Eng., vol. 35, no. 20, Oct. 15, 1931, pp. 1028–1029, 3 figs. Pacific Gas and Electric Co. carried out complete development of river to give 228,000 hp.; Tiger Creek plant contains two 30,000-kva. generators, each driven by 36,000-hp.; double-overhung impulse wheel; salt springs, with world's largest rockfill dam has 13,500-hp. vertical turbine driving 11,000-kva. generator; development includes reservoirs and regulating works and additional generating equipment to be installed at Bear River Reservoir, West Point and Electra. Similar description previously indexed from Power, Sept. 22, 1931.

CHUTE-A-CARON, CANADA. Putting the Harness On a Million Horses—II. Contract Rec., vol. 45, no. 41, Oct. 14, 1931, pp. 1245–1248, 7 figs. Further practical details covering construction of Chute-a-Caron, Saguenay, development; sand supply; crushing plant; grading of coarse aggregate; cement storage; concrete mixing plant; precautions against fire; other construction-plant buildings and equipment; electric power for construction plant.

I

IMPACT TESTING

NOTCHED-BAR. Die Entlastungskerbe (Relief Notch), A. Thum and S. Berg. Forschung auf dem Gebiete des Ingenieurwesens, vol. 2, no. 10, Oct. 1931, pp. 345–351, 20 figs. Tests on increase of endurance strength due to additional notches and drilled holes; diminution of notch effect explains test results; dynamic causes of spring effect produced by additional holes; useful transverse holes.

INDUSTRIAL MANAGEMENT

COST ACCOUNTING. Accurate Knowledge of Costs Vital in Effecting Economies, T. B. Frank. Iron Age, vol. 128, no. 19, Nov. 5, 1931, pp. 1163–1165 and 1221. Installation of modern accounting methods, including budget control, standard cost systems, together with proper distribution of overhead burden; recent developments in accounting practice to increase profits or decrease losses.

Effective Use of Cost Data. Nat. Assn. Cost Accountants, Bul.—Sec. 1, vol. 13, no. 3, Oct. 1, 1931, pp. 155–165. Value of accurate accounting records and cost data; representative cost make-up; cost progress report; features of cost-reduction work.

INVENTORY CONTROL. Inventory Control as Used by Taylor Instrument Companies of Rochester, N. Y. Nat. Assn. Cost Accountants—Bul., Section 1, vol. 13, no. 2, Sept. 15, 1931, pp. 91–111. Control system used in diversified and extensive business of technical nature, which presents many complex problems of production involving over 8000 different catalogued items of product, distribution being world-wide and largest of its kind in world; study and survey made within last three years of this control, including related departments in organization, by prominent national firm of industrial engineers also including decentralization of stock records and minimum of mechanical equipment.

OBSOLESCENCE. Anticipating Obsolescence—A New Demand on Production Men, R. E. Baker. Iron Age, vol. 128, no. 17, Oct. 22, 1931, pp. 1043–1046. Efficiency rather than productivity, must be new watchword; steps to guard capital against undue obsolescence resulting from scientific development.

PRODUCTION CONTROL. Production Planning, R. E. Flanders. Taylor Soc—Bul., vol. 16, no. 5, Oct. 1931, pp. 200–205, 7 figs. Outline of production control system on Jones and Lamson Machine Co. Springfield, Vt.

INDUSTRIAL PLANTS

FLOORS. Problem of Industrial Plant Floor, R. T. Elworthy. Can. Chem. and Met., vol. 14, no. 10, Oct. 1931, pp. 277–278, 2 figs. New material manufactured in Canada; Prodorite is new type of concrete in which specially prepared organic binder is employed in place of portland cement to bond together carefully selected and graded aggregate consisting of quartz or other acid-resistant stone; physical and chemical properties.

WINDOWLESS. Bold Pioneering in Construction Field Threatens Outworn Methods, R. D. Proctor. Glass Industry, vol. 12, no. 11, Nov. 1931, pp. 227–229, 7 figs. Design and constructional details of first windowless factory; pioneer development of Simonds Industries, Inc., artificial light; improved working conditions.

INTERNAL-COMBUSTION ENGINES

DESIGN. The International Combuston Engine and Its Performance, W. A. Tookey. Automobile Engr., vol. 21, no. 285, Oct. 1931, pp. 416–420. Correlation of performances of present-day types for stationary, marine, air, and land-transport purposes; speeds and cylinder capacity; weight; brake mean effective pressure; units of output and consumption; thermal efficiency; heat to walls, friction, etc.; gasoline engines; gasoline consumption; compression-ignition engine.

STEAM, VS. Power, A. Ewing. Engineering, vol. 152, no. 3951, Oct. 2, 1931, pp. 356–358; see also editorial comment, p. 353. Review of developments in power generation; milestones in history of internal combustion; for larger uses, steam engine has held its own during half-century of change; power stations equipped with large turbines and coal-fired boilers, using steam of high pressure and high superheat; selection of prime movers for oceangoing ships; from thermodynamic point of view Diesel engine still has small advantage; fuel for marine engines. Presidential address before Brit. Assn.

VALVE-SEATS. Prevention of Valve-Seat Erosion, E. M. Getzoff. Soc. Automotive Engrs.—Jl., vol. 29, no. 4, Oct. 1931, pp. 332–335, 7 figs. Investigation of problem of preventing valve-seat erosion under severe operating conditions in motor-truck and motor-coach engines; successful methods of securing aluminum-bronze rings to cast iron; advantages of flat-seat valve; method adopted for securing Mack alloy inserts.

[See also *Airplane Engines; Diesel Engines; Oil Engines.*]

IRON AND STEEL PLANTS

GERMANY. Das Hochofenwerk der Fried. Krupp A.-G. in Essen-Borbeck (The Blast Furnace Plant of Fried. Krupp A.-G. in Essen-Borbeck), E. Ackermann. Stahlbau (Supp. to Bautechnik), vol. 4, no. 9, May 1, 1931, pp. 102–105, 9 figs. Description of steel structures of great iron and steel plant, including blast-furnace steel frame, 58.7 m. high.

L

LIQUIDS

HEAT PROPERTIES. Isothermal and Adiabatic Compressibilities, Specific Heat, and Heat Conductivity of Liquids, H. Shiba. Inst. Phys. and Chem. Research—Sci. Papers, vol. 16, no. 325, Sept. 20, 1931, pp. 205–241, 6 figs. Author had previously directly determined compressibilities of liquids at atmospheric pressure and temperatures of 20 and 25 deg. or 25 and 30 deg. cent.; results since obtained are described together with previous ones.

LOCOMOTIVES

DESIGN. Illinois Central Effects Economies With Improved Front End. Ry. Age, vol. 91, no. 4, Oct. 3, 1931, pp. 513–515, 3 figs.; see also Ry. Mech. Engrs., vol. 105, no. 10, Oct. 1931, pp. 488–490, 4 figs. Tests of new design show notable reduction in locomotive back pressure and 12 per cent saving in unit fuel consumption; details of new front-end arrangement; comparative tests of Illinois Central 4-8-2-type locomotive no. 2447 equipped with old and new drafting arrangements; general arrangement of Mays locomotive front end.

FEEDWATER TREATMENT. Economy in Treating Locomotive Boiler Water, P. M. LaBach. Ry. Jl., vol. 37, no. 10, p. 20, 2 figs. Characteristics of good boiler water; losses due to scale formation; outline of feedwater treatment.

FUEL ECONOMY. Coal Economy on Illinois Central. Ry. Jl., vol. 37, no. 10, Oct. 1931, pp. 14–17, 3 figs. Review of coal savings on Illinois Central System; new design in drafting; save heat in boilers; examples of waste cited.

HIGH-PRESSURE. 4-6-2 High-Pressure (1706 lb. per sq. inch) Locomotive of Deutsche Reichsbahn (German State Railways), F. Witte and R. P. Wagner. Int. Ry. Congress Assn.—Bul., vol. 13, no. 10, Oct. 1931, pp. 823–844, 36 figs. partly on supp. plates. Difficulties encountered in transferring Loeffler principle from stationary plant to locomotive, and constructional methods that resulted; performance of heavy standard express locomotive of State Railways taken as basis; dimensions arrived at and adoption of closed high-pressure circuit.

OIL-ELECTRIC. Railways and Oil-Electric Locomotives. Engineer, vol. 152, no. 3953, Oct. 16, 1931, pp. 402–403. As indicated in Weir report, most important alternative form of tractor to electric locomotive is oil-electric; while electrification would seriously reduce consumption of British coal by railways, adoption of oil as fuel would entirely abolish it; it is unlikely that either electrification or oil-electric locomotives will be adopted for some years on scale envisaged in report.

PASSENGER. New Pacific Type Locomotives, Pennsylvania Railroad, E. C. Poultney. Ry. Engr., vol. 52, no. 620, Sept. 1931, pp. 348–353, 7 figs. New design of Pacific locomotive for express passenger services, incorporating features previously introduced with success for other locomotives, and included as modifications to Pacific type class K4.s. engines; dimensional outline diagram and main specifications.

SWITCHING. An Internal Combustion Shunting Locomotive. Engineer, vol. 152, no. 3952, Oct. 9, 1931, p. 390, 1 fig. Locomotive constructed by Avonside Engine Co. for service on Indian State Railways; prime mover is 4-cylinder gasoline engine, by W. H. Dorman and Co., of Stafford with cylinders 124 mm. diam. by 140 mm. stroke and develops 53 b.hp. at 1000 r.p.m., with max. of 65 b.hp. at 1450 r.p.m.

Switching Locomotives, Canadian Pacific Railway. Can. Ry. and Mar. World, no. 403, Sept. 1931, p. 581, 1 fig. Design and constructional features of eight-wheel locomotives built by Canadian Locomotive Co.; cylinders, $22^1/_2$ by 32 in.; driving wheels, 58 in.; boiler pressure 250 lb. per sq. in.; maximum tractive power 59,500 lb.; total weight in working order, 468,500 lb.; engine wheel-base 15 ft., 9 in.

THREE-CYLINDER. 4-6-2 Three-Cylinder Passenger Locomotive, Czechoslovakian State Rys. Locomotive, vol. 37, no. 470, Oct. 15, 1931, pp. 325–326, 2 figs. Design and constructional details; cylinders $20^{11}/_{16}$ by $26^3/_4$ in.; driving

wheels 6 ft. $4^3/_4$ in.; boiler pressure 185 lb. per sq. in.; weight of engine in working order 9.6 tons; total wheel base 36 ft. $1^1/_{16}$ in.

LUBRICATION

FRICTION COEFFICIENTS. Die innere Reibung und der Zustand des fluiden Stoffes (Internal Friction of Fluid Media), N. Gerasimov. Physikalische Zeit., vol. 32, no. 11, June 1, 1931, pp. 444–450, 6 figs. Equations for calculating friction; method for determining size of molecules; relation of heat of combustion to viscosity.

M

MACHINE SHOPS

STEAM HEATING. Die wirtschaftliche Beheizung von Werkstaetten (Economic Heating of Workshops), Kaiser. Waerme, vol. 54, no. 42, Oct. 17, 1931, pp. 783–787, 9 figs. Different systems of steam heating in shops; heating with reduced live steam, with exhaust steam of reciprocating engines and bleeder turbines; effect of regulation of temperature of air on economy of heating system.

MACHINERY

BASES—WELDING. Reducing Weight and Production Costs, C. M. Taylor. Welding Engr., vol. 16, no. 9, Sept. 1931, pp. 58–60, 5 figs. How bending brake and electric arc work together to improve design of machine bases and cut cost of manufacture.

FOUNDATIONS — DESIGN. Berechnung eines Generatorfundamentes mit stehender Welle (Design of Foundation for Vertical Axis Generator), O. Fuhrmann. Bauingenieur, vol. 12, no. 22–23, May 29, 1931, pp. 417–421, 9 figs. Detailed design of frame foundation for 27,000-hp. vertical electric generator; effect of vertical and horizontal vibrations on foundation; vibration of two-hinge frame under various conditions; critical speed of shaft and short-circuit moment.

VIBRATION. Vibration and its Isolation. Engineer, vol. 152, no. 3953, Oct. 16, 1931, p. 418, 5 figs. Results obtained with help of vibrograph instrument made by Cambridge Instrument Co.; great improvement effected in isolated foundation design by invention by Grey of foundation block isolated on springs; as applied to oil engines it consists of combined raft and outer shell and main foundation block to which engine is fixed.

MALLEABLE-IRON CASTINGS

PROPERTIES. Mechanical Properties of Malleable Iron on Various Sized Test-Bars, A. L. Norbury. Foundry Trade Jl., vol. 45, no. 787, Sept. 17, 1931, pp. 175–179, 16 figs. Transverse, tensile, bend, and elongation tests carried out on round and oblong test bars of various sizes of blackheart malleable and of whiteheart malleable, after one, two, and three anneals and with increased manganese content. Before Pan-European Foundry Congress.

MANGANESE STEEL

NEW TYPE. Fe—Mn—Ni—C a New Manganese Steel, J. H. Hall. Metal Progress, vol. 20, no. 5, Nov. 1931, pp. 69–72, 4 figs. Modified steel developed in laboratories of Taylor-Wharton Iron & Steel Co., and known as "Tisco Timang" steel; manganese steel made austenitic, strong, and tough by cooling in air after annealing, instead of by quenching in water, embrittlement of metal on subjecting it to temperatures up to dark red heat; welding rod for repairing cracked or worn manganese-steel parts.

MATERIALS HANDLING

NEW SYSTEM. Making Profits in 1931 by Cutting Costs Through New Handling System, G. R. James. Matls. Handling and Distribution, vol. 6, no. 6, Sept. 1931, pp. 19–21 and 38, 9 figs. Layout and operating features of new handling system installed in Appleton Electric Co., Chicago.

SHEET STEEL. Handling of High-Grade Sheet Steel—II, E. S. Lawrence. Blast Furnace and Steel Plant, vol. 19, no. 10, Oct. 1931, pp. 1344–1347, 5 figs. Romine patent No. 1,751,717 contemplates method and apparatus whereby sheet metal, strip, plates, or other heavy thin gage material may be carried in and out of cars in large compact units (preferably about 10-ton units) deposited or picked up and also braced for transportation without any manual handling; Freeze patent claims improved crate for shipment of metallic sheets which are adequate to hold not only sheets together in bundle form during shipment, but also to permit sealing of sheets against entrance of moisture.

METALS

ATMOSPHERIC CORROSION. Origin of Iron in Corrosion-Products Due to London Atmosphere, E. Wilson. Engineering, vol. 132, no. 3432, Oct. 23, 1931, p. 535. Chemical analyses of corrosion products on certain aluminum and copper conductors exposed to atmosphere on roof of King's College, London, showed that iron was present in considerable quantity; it would appear from results of experiments that origin of iron is largely if not entirely due to presence of iron pyrites in coal burned in ordinary manner.

TESTING. Les caractéristiques mécaniques des métaux à chaud (Mechanical Characteristics of Metals at High Temperatures), J. Galibourg. Science et Industrie, vol. 15, no. 213, Oct. 1931, pp. 455–462, 7 figs. Hardness, impact, torsional, bending, fatigue, and friction testing; tensile tests under usual conditions of testing at ordinary temperatures and tensile tests under constant loads; latter permit detailed study of phenomena which characterize behavior of metals under high temperatures.

Les métaux aux températures élevées (Metals at High Temperatures), J. Galibourg. Int. Congress Testing Matls.—Advance Paper, 1931, 9 pp., 6 figs. Author determines limit at which first signs of flow appear, ascertainable by means of Martens mirror elasticity meter, which has sensitivity of 0.001 mm.; first permanent sets, when produced, are arrived at in two hours; hope is expressed that connection will be established with more rapid test methods now being perfected.

MOLYBDENUM STEEL

TESTS. Effect of Molybdenum on Medium-Carbon Steels Containing 1 to 2.5 Per Cent of Manganese, G. Burns. Engineering, vol. 132, no. 3429, Oct. 2, 1931, pp. 447–448 and (discussion), 443, 3 figs. Steels used in investigation were made by crucible process, and were rolled into bars $1^1/_4$ in. in section; thermal critical ranges; mechanical properties; susceptibility to temper brittleness; mass effect. Before Iron and Steel Inst.

MORTISING MACHINES

ELECTRICALLY OPERATED. Electrically-Operated Mortising Machine. Engineering, vol. 132, no. 3431, Oct. 16, 1931, p. 510. Machine designed for use with either chain cutter or hollow chisel; motor is mounted on headstick and control box on side of column, with contactors operated by push buttons.

N

NITRIDATION

ALLOY STEELS. Surface Hardening by Nitrogen of Special Aluminum-Chromium-Molybdenum Steels on a Production Basis, W. H. Cunningham and J. S. Ashbury. Iron and Coal Trades Rev., vol. 123, no. 3318, Oct. 2, 1931, pp. 492–494; see also Engineering, vol. 132, no. 3430, Oct. 9, 1931, pp. 475–476, 2 figs. Explanation of process of nitriding as carried out productively by firm with which authors are connected. Before Iron and Steel Inst.

O

OIL ENGINES

AUTOMOTIVE. Oil Engines for Passenger Transport. Ry. Gaz., vol. 55, no. 13, Sept. 25, 1931, pp. 400–402, 6 figs. Design and operating details of engines produced by Associated Equipment G. and L. Gardner and Sons for use in road vehicles; power and consumption curves of latest A.E.C. Ricardo oil engine; horsepower fuel consumption and torque curves of new Gardner six-cylinder oil engine.

HIGH-SPEED. High-Speed Oil Engines. Engineer, vol. 152, no. 3953, Oct. 16, 1931, pp. 411–412. Review of position and record of progress made indicating those problems which have still to be faced in further development of this prime mover; direct-injection engines with piston swirl; engines employing ante-chamber and those employing auxiliary air chamber; what engineers have to strive for is high-speed engine of light weight capable of using efficiently wide range of fuels and giving performance under service conditions comparable with that of modern gasoline engine.

OXYACETYLENE CUTTING MACHINES

AUTOMATIC. Automatic Gas Cutting Central Control and Multiple Torch Operation, R. F. Helmkamp. Am. Welding Soc.—Jl., vol. 10, no. 9, Sept. 1931, pp. 36–38, 1 fig. Design and operation of automatic cutting machine for handling of plate; table gives data on gas pressure, gas consumption, cutting speed for steel thickness of $^1/_4$ to 6 in.

P

PENSTOCKS

DESIGN. Berechnung ganz oder teilweise gefuellter, frei tragender, duennwandiger Rohrleitungen mit beliebig geneigter Achse (Design of Full or Partly Filled Simply Supported, Thin-Walled Pipe Lines Inclined at Any Angle), R. Abdank. Bautechnik, vol. 9, no. 27, June 19, 1931, pp. 419–420, 5 figs. Theoretical mathematical discussion, with numerical examples, prompted by design of penstocks for Shannon hydroelectric plant.

PIPE LINES

OXYACETYLENE WELDING. New Lindeweld Process for Pipe Line Construction. Oxy-Acetylene Tips, vol. 10, no. 9, Sept. 1931, pp. 147–151, 8 figs. High-strength welds at high speed by special flame adjustment, use of special welding rod and new welding technique; average tensile strength of 73,000 lb. per sq. in. was obtained with average elongation of 24 per cent in $^1/_2$ in. and 22 per cent in 1 in.; average time for making Lindeweld with single-flame hand blowpipe in 20-in. pipe (5/16 in. wall) is 26 min.; with Lindewelder time per weld is reduced to 17 min.

PLATES

STRESSES IN. Schubknickversuche mit Wellblechtafeln (Shear and Buckling Tests of Corrugated Sheets), E. Seydel. Jahrbuch 1931 der Deutschen Versuchsanstalt fuer Luftfahrt, E.V., pp. 233–245, 24 figs.; see also Zeit. fuer Flugtechnik und Motorluftschiffahrt, vol. 22, no. 13, July 14, 1931, pp. 410–411, 1 fig. Mathematical and experimental investigation of buckling phenomena in corrugated and reinforced corrugated plates; effect of critical buckling load on fracture; results prove that assumption of orthogonal and anisotropic plate is satisfactory for approximate calculation.

POLISHING

OPTIMUM RATE FOR. Practical Research—A Tool for Cutting Costs, E. S. Heck, Abrasive Industry, vol. 12, no. 11, Nov. 1931, pp. 33–34, 36 and 38, 5 figs. Experiments show that within limits cutting rate increases directly with pressure; wheel wear per unit removal is greater when pressure becomes greater; increasing pressure with faster cutting makes it possible to polish more pieces per hour; graph illustrates how labor cost and set-up cost which vary with pressure may be plotted from test results and point of least cost found.

PRESSES

FORMING TOOLS FOR. Press-Tool and Fixture Design—IX and X, H. C. Lane. Engineer, vol. 152, nos. 3953 and 3954, Oct. 16, 1931, pp. 398–399, and Oct. 23, pp. 426–427, 13 figs. Oct. 16: Short-length chain making; final-stage curling tools. Oct. 23: Jigs and fixtures: spring coiling and compressing.

HYDRAULIC. 600-Ton Automatic Press. Engineering, vol. 132, no. 3429, Oct. 2, 1931, pp. 433–435, 1 fig. Continuous automatic feed is provided by rotating ring carrying six die blocks which are filled, inserted, withdrawn, and emptied without any stoppage of mechanism; machine, manufactured by Greenwood and Batley, and is capable of producing pressings up to rate of 12 per min. and of exerting any gross pressure up to 600 tons.

PUMPS

DESIGN. Higher Priced Materials Without Added Cost, L. H. Labaw. Product Eng., vol. 2, no. 10, Oct. 1931, pp. 446–448, 4 figs. One-piece die casting of double-acting reciprocating, single-cylinder pump eliminated eccentric machining and assembly operations and resulted in rigid units with surfaces inherently aligned.

FEEDWATER. High-Pressure Feed Pumps at Bradford, Engineer, vol. 152, no. 3954, Oct. 23, 1931, pp. 442–444, 7 figs. For feeding super-pressure boiler installed by T. Roles in Valley-road power station of Bradford Corp., there is electrically driven pump running at 2950 r.p.m. and steam turbine-driven unit running at 4000

r.p.m.; both manufactured by Mather and Platt, electrical set has low-pressure pump of 2 stages and high-pressure pump of 8 stages, while low-pressure pump of steam set has one stage.

Speisepumpen fuer Hochdruckdampfkraftwerke (Feedwater Pumps for High-Pressure Steam Power Plants), G. Weyland. Archiv. fuer Waermewirtschaft, vol. 12, no. 10, Oct. 1931, pp. 297–299, 6 figs. Determination of efficiency of feed pumps; QH curve indicating quantity handled in relation to pressure head; efficiency of pumps with very flat QH curve; performance of pumps in Berlin "West" power plant; prevention of steam formation in hot-water pumps with mixed preheating.

PUMPS, CENTRIFUGAL

PERFORMANCE CHARACTERISTICS. Centrifugal Pump Performance Characteristics, D. G. McNair. Power Engr., vol. 26, no. 307, Oct. 1931, pp. 385–387, 3 figs. Economics of pumping; centrifugal-pump characteristics; self-regulation; auto-regulation adjusted to duty point; characteristic curves with auto-regulator.

R

RAIL MOTOR CARS

BERMUDA. The Bermuda Ry.—Internal Combustion Drewry Rail-Cars. Locomotive, vol. 37, no. 470, Oct. 15, 1931, pp. 329–333, 7 figs.; see also Tramway and Ry. World, vol. 70, no. 19, Oct. 15, 1931, pp. 210–213, 13 figs. Similar description previously indexed from various sources.

GERMANY. Rail-Omnibuses on the German Railways. Ry. Gaz., vol. 55, no. 16, Oct. 16, 1931, pp. 492–493, 3 figs. Design and technical features of vehicles built by Henschel and Sohn A. G. Kassel of single-compartment type, accommodating up to 90 passengers and with provision for carrying light freight and mails; advantages of less weight, higher acceleration, lower capital cost, and more economical operation.

IRELAND. Diesel Rail Car, Donegal Railways. Ry. Gaz., vol. 5, no. 14, Oct. 2, 1931, p. 437, 2 figs. Design and construction details of first Diesel-engined rail car on railways of Great Britain or Ireland; steel chassis 28 ft. long, wheels 2 ft. 2 in.; Diesel engine of L2 type, having six-cylinders developing 74 b.hp. and 1300 r.p.m.; car weighs 7 tons and seats 32.

REFRIGERATING PLANTS

INSTRUMENTS. Measuring Actual Capacity, L. A. Philipp and R. H. Swart. Refrig. Eng., vol. 22, no. 4, Oct. 1931, pp. 234–239, 8 figs. Design and constructional features of new calorimeter scheme for determining evaporator refrigerating capacity of domestic-commercial machines; calorimeter heat loss; electric wiring diagram; experimental procedure, data, and results.

REFRIGERATION

CHARTS. Graphical Representation of Characteristic Data. Ice and Cold Storage, vol. 34, no. 403, Oct. 1931, pp. 248–251, 2 figs. To insure consistency and reliability of comparison, graphic methods of representation are indispensable; basic chart for condensers and evaporators; chart for calculating power consumption, allowing for clearance and irrespective of superheat.

ROLLING MILLS

BLOOMING MILLS, THREE-HIGH. Ueber Anordnung von Kalibern auf festilegenden Trio-Blockwalzen (Arrangement of Passes on Stationary Three-High Blooming Rolls), T. Dahl. Stahl und Eisen, vol. 51, no. 40, Oct. 1, 1931, pp. 1228–1232, 4 figs. Defects in passes of three-high mills; by reducing overpressure, corresponding reduction in pull is effected, and injurious effects of overpressure eliminated.

SHEET MILLS. Neerungen an Feinblech-Walzwerken (Improvements in Sheet Mills), C. Hoffmann. Stahl und Eisen, vol. 51, no. 42, Oct. 15, 1931, pp. 1283–1287, 16 figs. Mill for production of medium and thin sheets of high strength; mills for ordinary commercial and special thin sheets; continuous cold re-rolling mills; four-high mills.

ROLLS

CAST-IRON. Festigkeitseigenschaften gusseiserner Walzen (Strength of Cast-Iron Rolls), E. Scharffenberg. Stahl und Eisen, vol. 51, no. 41, Oct. 8, 1931, pp. 1249–1256, 12 figs. Determination of strength of rolls; disadvantages of separate or cast-on testbars; selection of proper cast-iron test pieces; influence of ferrostatic pressure on strength variations in rolls; high-temperature tensile tests; relation between hardness, tensile and bending strength, and deflection of roll.

GRINDING. Steel Mill Roll Finishing Embodies Peculiar Grinding Problems—1, H. J. Wills. Abrasive Industry, vol. 12, no. 11, Nov. 1931, pp. 15–16. Surface and finishes, roll characteristics, roll grinding machines, and cooling compounds.

S

SCREW MACHINES

AUTOMATIC. Les tours a décolleter automatiques modernes (Modern Automatic Screw Machines). Technique Moderne, vol. 23, no. 20, Oct. 15, 1931, pp. 689–693, 17 figs. Design and operation of representative types of French and foreign screw machines; feed for bar stock or by magazine.

SCREW THREADS

CUTTING. Cutting Single-threaded Screws of Broken Pitch, F. W. Shaw. Machy. (Lond.), vol. 39, no. 993, Oct. 22, 1931, pp. 101–103, 6 figs. Some screws whose pitch is not factor of pitch of lead screw can be cut without reversing lathe, nut being disengaged from lead screw at end of each cut and re-engaged at each beginning, correct re-engagement being secured by process of "thread matching."

SEAPLANES

CATAPULTS. Flugzeugkatapulte (Airplane Catapult), K. Schwaerzler. Zeit. fuer Flugtechnik und Motorluftschiffahrt, vol. 22, no. 14, July 28, 1931, pp. 425–428, 7 figs. Fundamental calculations in design of catapult; equipment for recording acceleration.

LANDING. Beitrag zur Frage der Belastungsannahmen fuer den Landungsstoss von Seeflugzeugen (Problem of Load Assumption for Landing Shock of Seaplane), J. Taub. Zeit. fuer Flugtechnik und Motorluftschiffahrt, vol. 22, no. 14, July 28, 1931, pp. 433–442, 4 figs. Theoretical investigation of effect of size of airplanes on landing shock; landing shock for flying boat and double-float plane; unsymmetric shock distribution for double-float plane; results obtained by landing-shock formulas developed by Pabst and Wagner.

SHAFTS

AUTOMOBILE, STRESSES IN. Stresses in Automobile Shafts, A. T. J. Kersey. Automobile Engr., vol. 21, no. 285, Oct. 1931, pp. 407–408, 3 figs. Mathematical investigation of stresses imposed on transmission shafting shows that sufficient elasticity should be allowed in braking gear, and that undue "fierceness" in brakes and particularly in clutch of motor-driven vehicle, is most undesirable.

SHELLS

DRAWING. Drawing One-Piece Hollow-Walled Shells, J. E. Fenno. Machy. (N. Y.), vol. 38, no. 2, Oct. 1931, pp. 88–90, 3 figs. Design of die that turns shell inside out to form double wall; sketch illustrates successive operations in producing double-walled shell in dial press.

SMOKE

DENSITY MEASUREMENTS. Measurement of Smoke Density and Soot Fall, W. A. Carter. Power, vol. 74, no. 19, Nov. 10, 1931, pp. 678–681, 9 figs. Air pollution in congested areas, with consequent effect on health and general cleanliness of community, largely due to emission of solid impurities from smoke stacks; first step in reduction of such pollution is measurement of density and duration of smoke emission; details of recorders and methods employed. Before Smoke Prevention Assn.

STANDARDIZATION

INTERNATIONAL. Stand der internationalen Normungsarbeiten (Status of International Standardization Work), K. Gramenz. V.D.I. Zeit., vol. 75, no. 43, Oct. 24, 1931, pp. 1331–1336. Review of international coordination of standards on threads, bearings, pipe lines, fittings, paper sizes, rivets, shipbuilding, engineering drawings, stationary boilers, couplings, aircraft, automobile parts, agricultural machinery, coal, orifices, etc.

STEAM

HIGH-PRESSURE. Higher Steam Pressures and Temperatures. Nat. Elec. Light Assn.—Pub., no. 154, Sept. 1931, 6 pp., 2 figs. Report includes statements of operating experience by three companies using 1200- to 1400-lb. steam equipment; reports from four manufacturing companies on high-pressure and temperature boiler and turbine installations; brief review of articles published during 1930 on subject.

Why High-Pressure Steam Has Low Total Heat, R. F. Sorrells. Power, vol. 74, no. 16, Oct. 20, 1931, pp. 572–573, 2 figs. Theory presented explaining reasons for decreasing total heat of saturated steam above 425 lb. pressure.

STEAM-ELECTRIC POWER PLANTS

DETROIT, MICH. Detroit Edison Has Completed Its High-Temperature Installation, R. M. Van Duzer, Jr. Power, vol. 74, no. 17, Oct. 27, 1931, pp. 591–595, 7 figs. Preliminary installation at Trenton Channel for determination of superheater performance; design and constructional details of superheater equipment at Delray; details of high-temperature turbine; data of turbine-generator and auxiliaries; table of chemical and physical properties of special steels used in high-temperature installation.

GREAT BRITAIN. Electricity Supply at Stockport. Engineering, vol. 132, no. 3432, Oct. 23, 1931, pp. 523–524. Present capacity of station is 55,500 kw., and comprises in addition to new unit, one 15,000-kw., one 5500-kw. and three 5000 kw. sets; steam raising plant consists of 11 boilers, with total output of 470,000 lb. per hr.; steam from turbine passes to two Escher-Wyss condensers, each of which has cooling surface of 10,760 sq. ft.; new switchgear consists of 11-panel metal board of duplicate busbar pattern.

LANSING, MICH. Moores Park Completed by 20,000-Kw. Unit No. 4. Power Plant Eng., vol. 35, no. 21, Nov. 1, 1931, pp. 1048–1052, 7 figs. Municipal power plant serving City of Lansing, Mich., now has total generating capacity of 65,000-kw. in four units, latest of 20,000-kw. capacity; boiler house addition contains four new stoker-fired steam generating units making 450-lb. 700-deg. steam for 55,000-kw. of total capacity, leaving former 250-lb. boilers for reserve.

STEAM ENGINES

TESTING. Essais d'une machine mono-compound a prelevement de vapeur (Testing of "Mono-Compound" Engine), H. Mouchelet. Associations Françaises de Propriétaires d'Appareils à Vapeur—Bul., vol. 12, no. 45, July 1931, pp. 179–184, 4 figs. Testing of engine with low-pressure cylinder in front of high-pressure cylinder; principal dimensions: high-pressure cylinder diam. 300 mm., low-pressure cylinder diam. 600 mm., stroke 600 mm., speed 130 r.p.m.

STEAM GENERATION

ELECTRIC. Can You Generate Cheaper Steam Electrically? A Question Asked and Answered, C. P. Kreuzer. Gen. Elec. Rev., vol. 34, no. 10, Oct. 1931, pp. 565–567, 4 figs. Problems involved in generation of small quantities of steam in remote location and its efficiencies are discussed; various electrically heated equipment for this purpose are illustrated and described.

STEAM PIPE LINES

CALCULATION. Designing High Temperature Steam Piping—1, A. McCutchan. Heat., Piping and Air Conditioning, vol. 3, no. 10, Oct. 1931, pp. 825–831, 7 figs. Design and constructional features of turbo-generator unit operating on steam at 1000 deg. fahr. at Delray, No. 3 station; reactions determined by grapho-analytical method; piping has high coefficient of expansion.

HIGH-PRESSURE. Draining High-Pressure Steam Mains. Power, vol. 74, no. 19, Nov. 10, 1931, pp. 674–675, 3 figs. In high-pressure plants as few traps as possible are installed, while some engineers advocate eliminating them altogether; practical discussion of proper methods of drainage-system designs; system layouts.

STEAM POWER PLANTS

ACCUMULATORS. Die Speicherung in Heizkraftwerken (Heat Storage in Combined Heating and Power Plants), L. Musil. Waerme, vol. 54, no. 43, Oct. 24, 1931, pp. 795–799, 8 figs. Economy of steam and hot-water accumulators are compared; it is shown that these two types of accumulator can be employed economically together; use of accumulators for peak loads.

ASH HANDLING. Ash Handling Systems Call for Close Study of Local Conditions. Power House (Mgmt.), vol. 25, no. 10, Oct. 1931, pp. 18–20, 4 figs. Economic features of ash-handling systems; separate or combined systems; cost considerations; advantages of various systems.

HEATING AND POWER. Die wirtschaftlichste Druckverteilung in Heizkraftwerken (Economic Pressure Distribution in Combined Heating and Power Plants), W. Goldstern. Waerme, vol. 54, no. 42, Oct. 17, 1931, pp. 767–772, 12 figs. Relations are derived for determination of most economical pressure distribution and are applied

to normal conditions; investigation of causes of present pressure limits.

HIGH-PRESSURE. Providing for Higher Pressures and Power Generation in Future, B. C. Stewart and E. D. George. South. Power Jl., vol. 49, no. 10, Oct. 1931, pp. 26–29, 3 figs. Degree to which design of modern industrial plant must consider possibilities of future well indicated in Point Breeze Steam Plant at Baltimore; intended for immediate use in supplying process steam; design provides for possibility of generation of electric power at expiration of existing contract with utility; general equipment and operation.

INDUSTRIAL—DESIGN. Economies in the Design and Construction of Industrial Boiler Plants, H. Bleibtreu. Blast Furnace and Steel Plant, vol. 19, no. 10, Oct. 1931, pp. 1362–1366, 4 figs. Analysis of costs for industrial boiler plants; general rules for economical layout; production costs of 1000 lb. of steam are under average conditions \$0.30 to \$0.50; \$0.15 to \$0.30 is for fuel, while interest and depreciation vary with load factor between \$0.08 and \$0.20; volume, structural steel weights and cost of boiler houses with coal bunkers; example of modern boiler-house design for large steel mill, 1000-hp. boilers, blast-furnace gas and powdered-fuel firing; example of small plant with two 500-hp. boilers.

1700 Lb. Industrial Plant of Novel Design Power Plant Eng., vol. 35, no. 21, Nov. 1, 1931, pp. 1058–1060, 5 figs. Ilse-Bergbau A. G. plant burns brown coal, uses stokers and pulverized fuel in same furnace, has three-cylinder back pressure turbines with steam reheaters and uses all exhaust steam in coal dryers; flow diagram of plant.

STEAM TURBINES

DESIGN. Mechanical Features of Turbines at Bremo, J. D. Schmidt. Power, vol. 74, no. 19, Nov. 10, 1931, pp. 676–677, 1 fig. Turbine units at Bremo station are largest 3600 r.p.m. machines installed in United States, but units of same capacity and speed have been operating in Canada and Europe; design, construction, and operating details.

EROSION. Erfahrungen mit Niederdruckturbinen-Beschauflung im Kraftwerk Klingenberg (Experience With Low-Pressure Turbine Blades in the Klingenberg Power Plant), F. Gropp and W. Ellrich. Elektrizitaetswirtschaft, vol. 30, no. 21, Oct. 1931, pp. 589–593, 11 figs. Current experience with regard to erosion of low-pressure blades of multiple-stage high-capacity turbines in BEWAG plant; preventive measures.

EXHAUST. Parsons Duplex-Exhaust Turbine. Engineer, vol. 152, no. 3955, Oct. 30, 1931, p. 468, 7 figs. partly on p. 464. Machine originated to provide sufficient exhaust area to enable large output to be obtained from single-cylinder turbines working on high vacuum; has rated output of 20,000 kw. at 3000 r.p.m.; it is of pure reaction type and is remarkable for its short overall length.

HIGH-TEMPERATURE. High-Temperature Turbine Experiment Making Progress, P. W. Thompson. Elec. World, vol. 98, no. 17, Oct. 24, 1931, pp. 732–736, 5 figs. Reasons why Detroit Edison Co. decided to try out high temperature installation; special design features of turbine and superheater; arrangements for continuous check on turbine performance; metal stress at 1000 deg. fahr.

STEEL

ALLOY. See *Steel Castings.*

CHROMIUM. See *Chromium Steel.*

CHROMIUM—NICKEL. See *Chromium—Nickel Steel.*

MANGANESE. See *Manganese Steel.*

MOLYBDENUM. See *Molybdenum Steel.*

STEEL CASTINGS

ALLOY STEEL. Legierter Stahlguss (Alloy Steel Castings), E. Kothny. Giesserei, vol. 18, nos. 31 and 32, July 31, 1931, pp. 613–618 and Aug. 7, pp. 635–639, 2 figs. Properties and application of manganese, nickel, vanadium, chromium, chromium-nickel, titanium, silicon and copper steel castings.

T

TAPS

COLLAPSIBLE. Collapsible Taps. Machy. (Lond.), vol. 39, no. 993, Oct. 22, 1931, pp. 105–107, 7 figs. Threading pipe flanges with receding collapsible tap of detachable-head type; cutting straight thread, 25 in. long, in piece of seamless tubing with collapsible tap provided with extra long body; set-up for tapping pipe flanges, in which expanding collapsible tap is equipped for boring tapered hole in advance of chasers, collapsible tap equipped with boring and reaming cutters, as well as chasers, for machining bearing seats in differential housing.

TESTING MACHINES

DESIGN. Zur Lagerung der Druckplatten von Knickmaschinen (Bearings of Compression Plates of Buckling Test Machines), Petermann. Stahlbau (Supp. to Bautechnik), vol. 4, no. 16, Aug. 7, 1931, pp. 184–186, 7 figs. Theory of design of machines for testing strength of compression members in buckling; critical review of construction of several existing machines, including those of U. S. Bur. Standards, pointing out their defects and ways of eliminating them.

RIEHLÉ. Riehlé Multi-lever Testing Machine, P. F. Foster. Machy. (Lond.), vol. 39, no. 995, Nov. 5, 1931, pp. 165–167, 7 figs. Design and operation of 25-ton vertical testing machine; diagram showing recording gear and automatic poise drive mechanism on Riehlé machine; arrangement for calibrating.

THERMODYNAMICS

CONVECTION. La convection calorifique (Calorific Convection), Veron. Science et Industrie, vol. 15, nos. 212 and 213, Sept. 1931, pp. 401–412 and Oct., pp. 463–469, 23 figs. Actual situation of work carried out in various directions on extremely delicate question of calorific convection between fluid and partition; application of equations to design of surface heat exchangers.

PRINCIPLES. Conduction, convection et rayonnement de la chaleur (Conduction, Convection, and Radiation of Heat), L. Kohler. Associations Françaises de Propiétaires d'Appareils à Vapeur—Bul., vol. 12, no. 45, July 1931, pp. 160–169, 1 fig. General outline of principles.

RESEARCH IN. Forschungsarbeiten auf dem Gebiete der technischen Thermodynamik (Research in Field of Engineering Thermodynamics), M. Jakob. Forschung auf dem Gebiete des Ingenieurwesens, vol. 2, no. 10, Oct. 1931, pp. 371–374, 4 figs. Report on 31 papers on thermodynamic problems published in Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, dealing with metal, steam, ammonia, carbon dioxide, nitrogen oxide, air and oxygen, and organic substances.

U

UNIVERSAL JOINTS

NOVEL TYPE. Novel Universal Joint. Engineer, vol. 152, no. 3954, Oct. 23, 1931, p. 445, 3 figs. Joint, manufactured by Emde and Meissner, of Solingen, Rhineland, under German and foreign patents; first designed for special machine in firm's works, it has proved so successful in service that it is now produced in standard sizes for transmission of large and small torques at speeds up to 10,000 r.p.m.; similar type is being manufactured for automobile work.

V

VACUUM TUBES

INDUSTRIAL APPLICATION. Electron Tube in Machine Design, R. F. Yates. Machy. (N. Y.), vol. 38, no. 2, Oct. 1931, pp. 95–96, 1 fig. How vacuum tube, photoelectric cell, and grid-glow tube are being used by machine designers for grading, measuring, and accounting.

VALVES

STEAM. Safety Valves, D. MacNicoll. Engineer, vol. 152, no. 3954, Oct. 23, 1931, p. 445. Review of paper before Institute of Marine Engineers; after discussing requirements of modern high-duty water-tube boiler; author suggested modification to present rules; modification is summed up under following two headings: safety valve area and accumulation trial.

W

WAGES

PROBLEM OF. Wages Problem. Engineer, vol. 152, no. 3955, Oct. 30, 1931, p. 458. There is difference between wages actually paid and their purchasing value, and attempts are now being made to establish basis of comparison that will allow of wage factor being more accurately determined in international exchanges; investigation is being undertaken by International Association for Social Progress.

WELDING

COPPER ALLOYS. See *Copper-Silicon Alloys.*

ELECTRIC. See *Electric Welding, Arc.*

STEEL. See *Chromium-Nickel Steel.*

WELDING MACHINES

MODERN. Les Machines à souder modernes et leurs applications (Modern Welding Machines and Their Applications), P. Neumayer. Société Française des Electriciens—Bul., vol. 1, no. 8, Aug. 1931, pp. 846–855, 11 figs. Equipment generally described and illustrated.

WELDS

ANALYSIS. Factors Affecting Steel Weldability, W. E. Stine. Elec. World, vol. 98, no. 18, Oct. 31, 1931, pp. 786–788, 6 figs. Lincoln Electric Co. investigated effect of chemical constituents of steel upon welding results and porosity in particular; carbon arc welding with shielded arc offered best means of studying problem; investigation was largely confined to determining causes of slag holes, since causes of cracks are reasonably well understood.

FATIGUE. Fatigue Properties of Welds, R. A. Weinman. Am. Welding Soc.—Jl., vol. 10, no. 10, Oct. 1931, pp. 12–18, 21 figs. Mechanical properties of metals deposited by means of atomic hydrogen flame in form of welds; fatigue tests on built-up specimens of metal were conducted at Rensselaer Polytechnic Institute at Troy, N. Y., by Moore fatigue machine; microphotographs illustrate effect of fatigue stressing on crystal structure; behavior of welded structures under fatigue stress does not differ fundamentally from forged and rolled metal.

HEAT TREATMENT. The Relief of Welding Strains by Annealing, C. H. Jennings. Am. Welding Soc.—Jl., vol. 10, no. 9, Sept. 1931, pp. 26–29, 3 figs. Interpretation of results obtained from tests conducted on elimination of residual stresses in plate; specimens made from hot-rolled low carbon steel were welded with $^{5}/_{32}$-in. dia. uncoated electrodes, using about 140 amp. welding current; soaking time, stress curve.

X-RAY ANALYSIS. X-Ray Examination of Welded Pressure Vessel Seams, A. J. Moses. Combustion, vol. 3, no. 3, Sept. 1931, pp. 17–20 and 35, 11 figs. With recent formulation of A.S.M.E. Code for welded boiler drums, technique and methods of testing used in manufacture of welded drums have taken on added interest and importance; outline of X-ray method of testing; features of installation of X-ray equipment which is representative of latest development in this field.

WIRE

TESTING MACHINES. Neue Pruefmaschinen zur Bestimmung der Wechselfestigkeit fuer umlaufende Biegung (New Rotary Bending Machines for Repeated-Stress Testing), W. Schwinning and E. Dorgerloh. Zeit. fuer Metallkunde, vol. 23, no. 6, June 1931, pp. 186–188, 6 figs. Machine for testing wires of 1.8 to 5 mm. diam. developed by authors.

WIRE-DRAWING MACHINES. Drahtzieherei und Drahtverarbeitung (Wire Drawing and Wire Finishing), A. Bahis and Eilenburg. Dinglers Polytechnisches Jl., vol. 112, no. 9, Sept. 1931, pp. 145–150, 6 figs. Drawing practice with older and latest equipment; average outputs; design, operation, and output of wire-straightening equipment.

WIRE ROPE

TESTING. Equalizing Load on Elevator Ropes, W. P. Frost. Power, vol. 74, no. 19, Nov. 10, 1931, pp. 684–685. Rope-loading tests; loading due to bending; record of rope life on high-rise cars in Equitable Life Assurance Society's Building, New York City; long rope life; equalizing compensation ropes.

WIRE SCREEN

WELDING. Resistance Welding of Metal Fabric, W. T. Ober. Am. Welding Soc—Jl., vol. no. 9, Sept. 1931, pp. 50–52, 3 figs. Design and operation of machines for electric welding of fabric made up from number of individual steel rods or wires where mesh is square or rectangular in shape made by welding each wire or rod that it crosses at points where they cross; 30 or 35 transverse wires welded to all longitudinal wires per minute, this being on fabric for 9- and 10 ft. road reinforcement.

WOOD

COMBUSTION OF. The Combustion Characteristics of Wood. Combustion, vol. 3, no. 3, Sept. 1931, pp. 44–45, 1 fig. Characteristics of wood as fuel; curves illustrating composition of flue gas, weight of gas required and weight of products of combustion of wood.